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# Socioeconomic Forecasting

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# JOINT TRANSPORTATION RESEARCH PROGRAM

INDIANA DEPARTMENT OF TRANSPORTATION  
AND PURDUE UNIVERSITY



## SOCIOECONOMIC FORECASTING

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<b>16. Abstract</b> The role of the REMI Policy Insight+ model in socioeconomic forecasting and economic impact analysis of transportation projects was assessed. The REMI PI+ model is consistent with the state of the practice in forecasting and impact analysis. REMI PI+, like its competitors, is vulnerable to the trends contained in the historical data it uses, especially recent trends. After the most recent periodic update in data, the performance of the REMI PI+ model improved, that is, it produced long-term forecasts that were more credible. Zonal-level population and employment forecasts for direct input to the Indiana Statewide Travel Demand Model (ISTDM) can be achieved by applying disaggregation regression methods. Indiana University's Center for Econometric Model Research (CEMR) model is also a sound forecasting model. Because of the knowledge of in-state economists, the CEMR-IBRC model could provide forecasts of the Indiana economy that reflect characteristics not known to out-of-state forecasters. The researchers also examined economic impact analysis models that are possible alternatives to REMI PI+. Acquiring a new economic impact analysis package does not seem necessary for INDOT, if REMI forecasts can be adjusted to (a) accommodate recent and reasonable expected trends in the Indiana economy, and (b) meet the geographic (TAZ) needs of the ISTDM. MCIBAS—which is currently used by the Indiana Department of Transportation—is a good hybrid system to use in the economic impacts analysis of transportation projects. Indiana University's CEMR is capable of conducting economic impact analyses, with local knowledge of the Indiana economy, at a cost lower than REMI's. However, INDOT would have to decide whether these potential advantages justify changing the present relationship with REMI. In cases where the credibility of data, forecasts, and/or impact analyses needs to be verified, an INDOT version of an expert panel along the lines of Michigan's Transportation Technical Committee could be convened.					
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## EXECUTIVE SUMMARY

### SOCIOECONOMIC FORECASTING

#### Introduction

Because the traffic forecasts produced by the Indiana Statewide Travel Demand Model (ISTDM) are driven by the demographic and socioeconomic inputs to the model, particular attention must be given to obtaining the most accurate demographic and socioeconomic forecasts.

The Regional Economic Models, Inc. (REMI), model, which was customized for the state of Indiana, is the fundamental tool employed by Indiana Department of Transportation (INDOT) to provide long-range socioeconomic forecasts that are used as inputs to the ISTDM. In the recent development of its 2035 long-range plan, INDOT attempted to use the REMI model for the long-range socioeconomic forecasts. For Indiana's large manufacturing sector, the REMI forecast for employment was extremely pessimistic, predicting that total employment would not return to 2007 levels until 2035. Instead, INDOT used a forecast from Woods & Poole, which showed a short-term employment reduction, followed by modest levels of employment growth extending to 2035.

The use of the REMI model as the INDOT simulation tool to test policy alternatives raised two concerns: (1) can REMI long-range socioeconomic forecasts be used as inputs to the ISTDM, and (2) does the REMI model outperform alternative economic impacts models that INDOT could select to meet its needs.

The objective of this research project was to review REMI's socioeconomic forecasting process and assess the appropriateness of using REMI forecasts/output within the INDOT planning process. Specific objectives included the following:

- Review INDOT's current REMI socioeconomic forecast relative to the most recent economic data.
- Evaluate the quality of REMI economic model output compared to forecasts from other available economic impact analysis models.
- Recommend what models might be used as economic forecasting tools to meet INDOT forecasting, economic impact assessment, and other research and planning needs.
- Develop a plan for creating an expert panel for INDOT to assess the extent to which economic forecasts are consistent with what is happening in the Indiana economy.

#### Findings

- The REMI models are consistent with the state of the practice in forecasting and impact analysis. A REMI model,

like its competitors, is vulnerable to the trends contained in the historical data it uses, especially recent trends. After the most recent periodic update in data, the performance of the REMI PI+ model improved, that is, it produced long-term forecasts that were more credible.

- Transportation infrastructure appears to be a necessary, but not sufficient, condition for generating economic development. Transportation infrastructure has a varying degree of significance on a firm's likelihood of locating in a specific area, combined with four other factors: labor, markets, fiscal, and agglomeration.
- A case study served as a reminder that a single transportation improvement project—even a major one—is not likely to have economic impacts at the statewide level that are significant. Because REMI operates at the state level, significant impacts at the local and corridor levels do not show up without special efforts at post-processing the REMI results.
- Indiana University's Center for Econometric Model Research (CEMR) is capable of conducting economic impact analyses, with local knowledge of the Indiana economy, at a cost lower than REMI's. However, INDOT would have to verify that confidence in a CEMR economic impacts analysis of transportation projects is justified.

#### Implementation

This study has confirmed that REMI is a model that uses standard methodology and, when using historical data that reflects long-term trends, REMI produces forecasts of employment and income that are suitable for use in INDOT's ISTDM.

The study has also identified an alternative source of such forecasts. Indiana University's CEMR is affiliated with the Indiana Business Research Center (IBRC). The CEMR model is an econometrics model, and tends to be more accurate as a predictive model. Its forecasts can be used to adjust REMI employment forecasts for the state of Indiana, because they are built upon the knowledge of local economists. The CEMR can customize its forecasts to meet the needs of INDOT's ISTDM. Because both REMI and CEMR can provide reliable information needed by INDOT for its ISTDM, INDOT can decide whether to continue its established relationship with REMI or begin to work with in-state CEMR, based on factors such as cost and responsiveness.

In cases where the credibility of data, forecasts, and/or impact analyses needs to be verified, an INDOT version of an expert panel could be convened. A proposed structure for an expert panel is outlined in the report.

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## 1. INTRODUCTION

### 1.1 Background and Objective

#### 1.1.1 Project Background

A statewide travel forecasting model is used to identify statewide travel patterns and their impacts on the transportation facilities across a state in a given period. Statewide models provide an analytical framework for assessing transportation system performance and deficiencies, and are used in long range plan development, systems level project analysis. Their models also provide the spatial analytical framework for transportation management systems. Statewide models can encompass both passenger and freight issues. The models provide forecasts for a variety of transportation modes, including highways, urban transit systems, intercity passenger services, airports, seaports, and railroads. Approximately half of the 50 states have created statewide models. Most of those models resemble urban transportation planning (UTP) models in structure (1). In the mid-1990s the first Indiana Statewide Travel Demand Model (ISTDM) was prepared for Indiana Department of Transportation (INDOT) using TransCAD software by Cambridge Systematics, Inc. (CSI), and Bernardin, Lochmueller and Associates, Inc. (BLA) (2). The ISTDM is a critical tool in forecasting Indiana state travel and analyzing statewide traffic impacts. In addition, the ISTDM provide output that serves as a resource to the Major Corridor Investment Benefit Analysis System (MCIBAS) used to analyze the relative benefits of competing highway projects throughout the state (3).

During the past decade, dramatic improvements were made in socioeconomic and network databases, tools for accessing these databases, and computational power (1). Because the traffic forecasts produced by the ISTDM are driven by the demographic and socioeconomic data supplied as inputs to the model, particular attention must be given to obtaining the most accurate demographic and socioeconomic forecasts as input for the ISTDM (2). Population and employment data forecasts through 2035 are needed for use at the traffic analysis zone (TAZ) level. To portray the location of trip ends in the ISTDM, Indiana is divided into more than 4,000 TAZs. The forecasts of additional socioeconomic variables, including households, household size, household auto ownership, and household income are also essential for developing the statewide travel forecast.

The Regional Economic Models, Inc. (REMI), model, which was customized for the state of Indiana, is the fundamental tool employed by INDOT to provide long-range socioeconomic forecasts that are used as inputs to the ISTDM. As a nationally-recognized dynamic economic model, the REMI simulation model uses an input-output framework expanded to be sensitive to a number of policy variables, several which are transportation-based. In the most recent development

of the socioeconomic forecasts for the 2035 long-range plan, INDOT attempted to use the REMI model for the long-range forecast (5). Manufacturing industry is of vital importance and serves a large share of Indiana's total employment. Due to the big drop in manufacturing employment since 2005, the REMI (version 1.15) forecast for total employment was extremely pessimistic, predicting that total employment would not return to 2007 levels until 2035. Based on a consultant's recommendation, INDOT used a reasonable forecast from Woods & Poole, which showed a short-term employment reduction, followed by modest levels of employment growth extending out to 2035.

The effects of investments in transportation infrastructure, on economic development, especially highways, have recently drawn much more attention than at any time in the past decades. The National Environmental Policy Act (NEPA) in 1969 guided all Federal agencies to make project decisions using a systematic interdisciplinary approach that balances engineering and transportation needs with socioeconomic and natural environmental factors (FHWA-NEPA). The 1998 Transportation Equity Act for the 21st Century (TEA-21) emphasized consideration of economic growth in a large, discretionary program, and recognized economic development as a decision factor in project evaluation. In addition, subsequent legislation required the Federal Highway Administration (FHWA) consider the economic development of highway initiatives in making funding allocations decisions across candidate projects (6).

Investments in transportation aimed at spurring economic development have been adopted by some states, in addition to carrying out projects with the basic goal of capacity expansion to meet projected demand (6). State DOTs such as INDOT incorporated economic development in project evaluation and listed this decision criterion as an essential element in its long-range plan (7). In late 2005 Indiana Governor Mitch Daniels launched an aggressive 10-year, \$12 billion transportation plan known as "Major Moves" to improve and expand Indiana's highway infrastructure. Since the Major Moves program's inception in 2006, approximately \$2.9 billion has been spent on new and capacity expansion highway projects within 39 corridors. It is anticipated that \$3.85 billion will be spent on an additional 65 corridors by the end of the program in 2015. The Indiana Long-Range Transportation Plan requires corresponding benefit-cost analyses of these projects and economic development impact analyses of the improvements.

As a key component of the MCIBAS, the REMI model has been employed by INDOT to help evaluate effects of transportation investments on the state economy by assessing the relative costs and benefits of proposed major highway corridor projects associated with the long-range plan. In 2009 the REMI model was used in conjunction with other analysis tools to estimate the economic benefits of multimodal freight projects.

### 1.1.2 Motivation of Study

The use of the REMI model as the INDOT simulation tool to test policy alternatives raises two concerns: (1) can REMI long-range socioeconomic forecasts be used as inputs to the ISTDM, and (2) does the REMI model outperform alternative economic impacts models that INDOT could select to meet its needs.

Gkritza et al. (8) developed a quantitative tool that can be used by INDOT staff at the project development phase to estimate the economic development effects of different types of highway investments. REMI forecasts based on the economic downturn later in the first decade of the twenty-first century have projected weak economic recovery. This raised concerns among INDOT transportation planners about the reliability of the REMI economic forecasts and the implications for INDOT use of REMI data in various forecasting models. INDOT was particularly concerned about use of the REMI forecast output with MCIBAS for the 2010–2035 Long-Range Transportation Plan and Indiana Multimodal Freight and Mobility Plan. As a consequence, INDOT saw a need to have the REMI output reviewed and have alternate forecasting models evaluated for their potential use.

### 1.1.3 Objective

The objective of the research project is to review REMI’s socioeconomic forecasting process and other similar tools to assess their quality and assess the appropriateness of using REMI forecasts/output within the INDOT planning process. Specific objectives include:

- Review INDOT’s current REMI socioeconomic forecast relative to the most recent economic data.
- Evaluate the quality of REMI economic model output compared to forecasts from other available economic impact analysis models.
- Recommend what models might be used as economic forecasting tools to meet INDOT forecasting, economic impact assessment, and other research and planning needs.
- Develop a plan for creating an expert panel for INDOT to assess the extent to which economic forecasts are consistent with what is happening in the Indiana economy.

## 1.2 Review of REMI’s Role in INDOT Practices

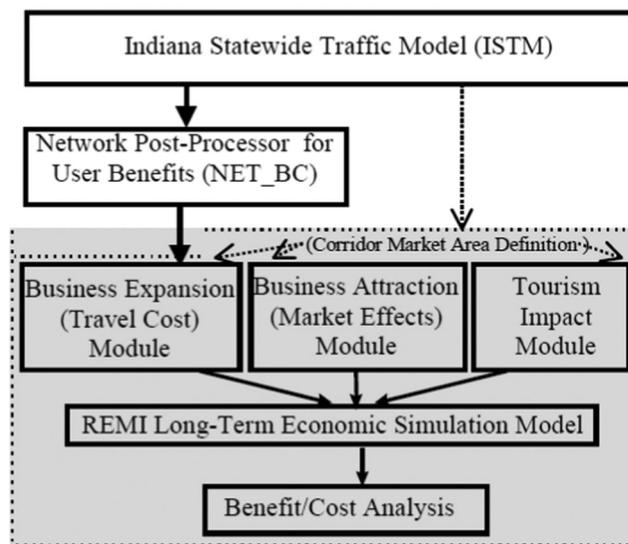
### 1.2.1 Major Corridor Investment-Benefit Analysis System (MCIBAS)

The MCIBAS is an economic analysis tool developed for the Indiana Department of Transportation (INDOT) to assess the costs and benefits of proposed major highway corridor projects. MCIBAS consists of a series of models: Indiana Statewide Travel Model (ISTM), User Benefit Analysis (NET\_BC), Economic Impact Modules (Business Expansion, Business

Attraction, and Tourism), REMI Simulation Model, and Benefit/Cost Analysis. The five modules shaded in Figure 1.1 comprise the Economic Impact Analysis System. The ISTM embedded in MCIBAS estimates the direct impacts of major highway improvements on existing and future traffic. In addition, the MCIBAS process considers the economic benefits from the expansion of existing businesses and the attraction of new businesses in the corridor study area that result from the increased accessibility and lowered cost of delivery derived from an improved transportation system (5).

NET\_BC is a post-processor program that is used to estimate direct user benefits of transportation investment. It can read ISTDM results and translate the predicted traffic changes into estimates of the monetized value of user travel time, vehicle operating cost and safety benefits. The Business Expansion module reads NET\_BC results and translates them into direct impacts on business operating costs and household disposable income. The Business Attraction module takes economic information on the corridor market area and translates it into factors that directly affect industrial business attraction. The Tourism module takes tourism market information and translates it into factors directly affecting tourism attraction (3).

The REMI Model provides the baseline economic forecast data that drives MCIBAS to estimate the full economic impacts of a highway project. REMI takes the direct economic impacts as assessed by the preceding three modules, then forecasts the total (direct and secondary) business output, income and population changes for the long-term period.



**Figure 1.1** MCIBAS components for long-term benefit/cost analysis. Shaded elements are internal to the economic impact analysis system. (Source: (3).)

1.2.2 INDOT 2010–2035 Long Range Transportation Plan

Subject to the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), the INDOT 2010–2035 Long Range Transportation Plan provides a vision for future developments and investments on the INDOT state transportation system. This plan addresses the eight statewide planning factors in SAFETEA-LU and presents a multi-modal overview through 2035 (5).

REMI long-term forecasts and Woods & Poole (9) forecasts were combined to produce population and employment forecasts for the state from 2010 to 2035. The forecast that INDOT used in the 2035 update statewide travel demand model was an older 2006 REMI forecast (10) which produced a 2035 employment total of 4.4 million in Indiana. For evaluating the Major Moves program in the plan, the REMI model within MCIBAS was used to assess the economic impacts of proposed projects. For identifying and prioritizing candidate projects, benefit/cost analysis within MCIBAS was conducted by taking REMI impact analysis results as inputs.

1.2.3 Indiana Multimodal Freight and Mobility Plan

The Indiana Multimodal Freight and Mobility Plan was developed to guide the state of Indiana’s future freight policy, provide a framework to guide future decisions regarding freight transportation investments, and ensure the efficient use of resources to support system wide objectives. In addition to looking at the current and future freight flows and the needs of current users of the system, the Plan also identified economic development opportunities related to the enhancement of Indiana’s freight infrastructure. The Plan will support INDOT’s Long-Range Transportation Plan, and in so doing would address how freight mobility impacts the entire transportation system of Indiana (11).

The evaluation methodology is based on an approach for estimating the economic benefits of freight projects using the REMI model. The general procedures for the methodology are shown in Figure 1.2. Three types of freight-related infrastructure improvements—highway capacity improvements; highway geometric improvements; and rail improvements—have been addressed. The final inputs as a matrix of user benefits to REMI in the last steps of the process are similar in most freight projects, but the inputs in the initial steps of the process differ, based on the techniques used to develop the data that will be input into the final REMI application.

Figures 1.3, 1.4, and 1.5 that follow were created by the researchers, based on the steps described in the *Indiana Multimodal Freight and Mobility Plan* (11). The process for evaluating auto and non-heavy truck economic impacts (Figure 1.3) includes two applications of REMI Policy Insight+. One application produces long-range employment forecasts used in estimating the industry share of auto benefits. The other application allows calculation of macroeconomic benefits that might accrue as a result of the construction of the roadway improvement. No models estimate business attraction and tourism benefits/impacts of transportation investments.

In similar fashion, to evaluate auto and non-heavy truck economic impacts, REMI was used to make long-range forecasts as well as economic impact analysis in the process of truck impact evaluation. However, the process is relatively complex, because the two types of industry share are separately estimated as truck services and in-house truck services. Hence, two matrices, with or without transportation and warehousing industry, comprise the final REMI input. This is depicted in Figure 1.4.

A rail improvement project as shown in Figure 1.5 does not have modules similar to the ISTD and NET\_BC to produce monetized user benefits. It is assumed that these data would be provided by the project sponsor when it is submitted for funding consideration.

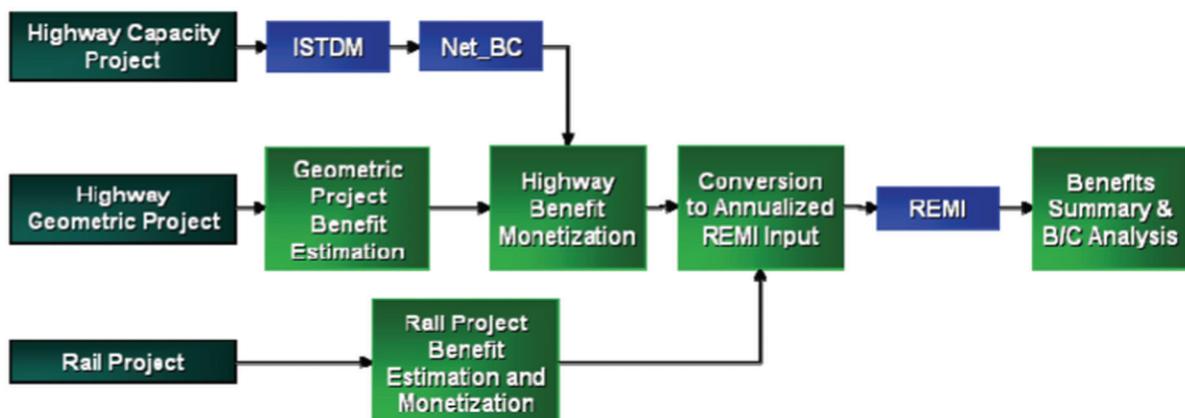


Figure 1.2 Freight project evaluation methodology. (Source: (11).)

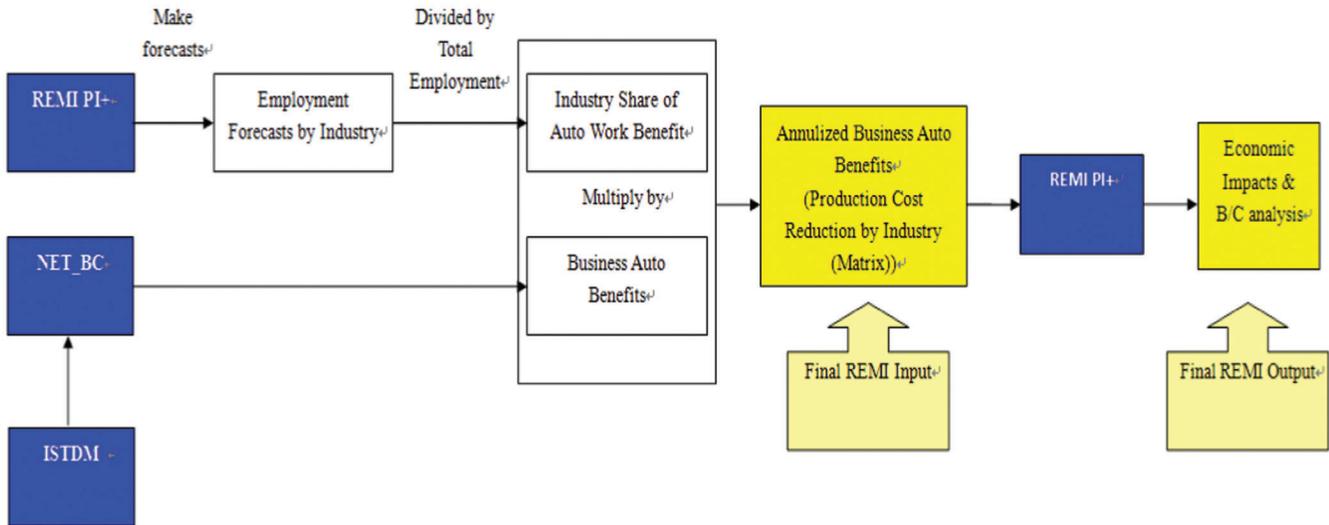


Figure 1.3 Process of auto and non-heavy truck economic impacts evaluation.

### 1.3 Report Organization

This report begins with an introduction to the background and development of the current ISTDM and long-range plan of INDOT. A review of REMI’s application in recent INDOT practices was made for understanding the role of REMI in the long-range planning, travel demand model and statewide improvement projects.

The study objective is to develop efficient forecasts of socioeconomic data as inputs to ISTDM. The first step in

doing this is to investigate regional and state experiences in developing socioeconomic forecasting. The second step will be to identify socioeconomic variables and data sources for the ISTDM. The next step is to develop a framework to combine available data sources with REMI forecasts for socioeconomic forecasts. Finally, regression-based method and aggregation method are discussed to obtain forecasts results in desired levels, so that it can be used effectively for ISTDM.

Another objective for this study is to compare the REMI model currently used by INDOT with a variety

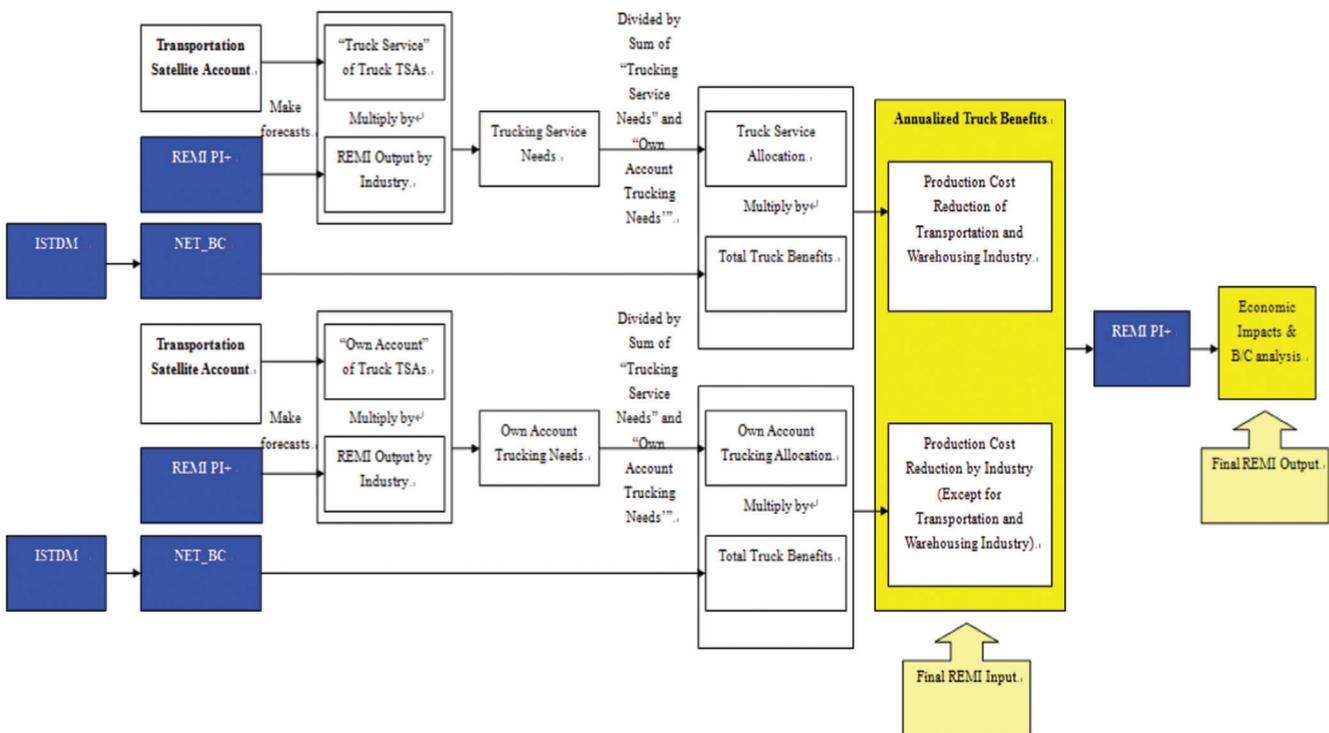
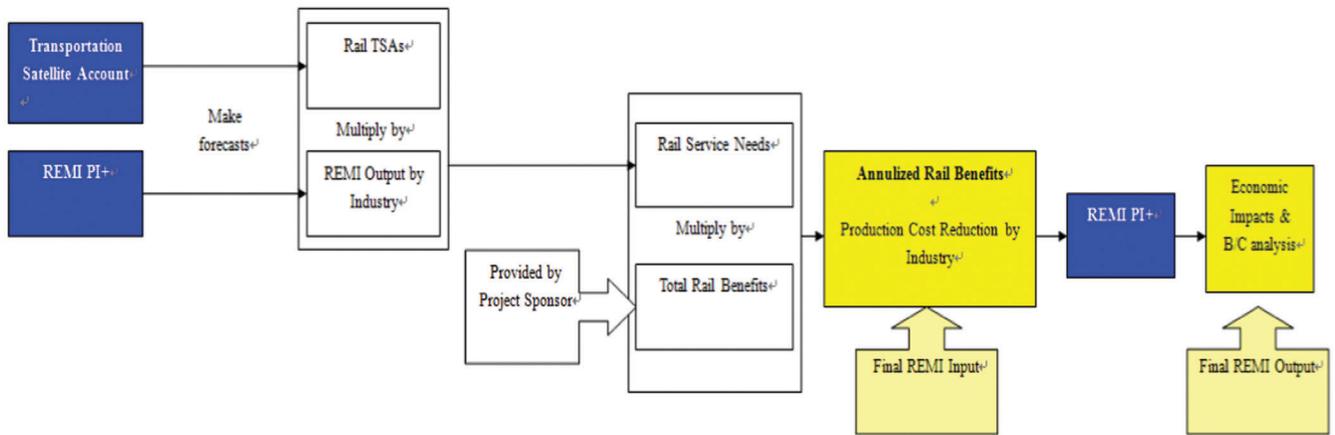


Figure 1.4 Process of truck economic impacts evaluation.



**Figure 1.5** Process of rail economic impacts evaluation.

of alternative economic impact analysis models, and suggest how INDOT can efficiently use REMI in its future projects. First, general classifications and indices of economic impacts are illustrated. Second, based on a comprehensive review of methodologies and findings of state DOTs, several popular economic impact analysis models of different types are introduced. Evaluation and comparison were conducted for the models. Finally, a real project is used to review REMI impact analysis.

To identify the mechanisms by which transportation investment affects regional economic growth, a review of manufacturing location theory and decisions was conducted for this study. After reviewing the benefits and returns from highway system investment, transportation investment types and economic development classifications are listed. Based on the analysis of Indiana manufacturing employment, the study discusses the underlying business location surveys and theories. Also, manufacturing location decision factors associated with transportation infrastructure are examined.

In order to fine tune REMI forecasts, the potential for an expert panel to make modifications to the economic model results is explored. The research also addresses how economic development is studied across states and describes existing highway-related economic development programs and policies operated by state transportation agencies. The final step of this study involves the documentation of the results and conclusions as to the relationship between different types of highway investment and long-term economic development, with specific reference to the State of Indiana. Directions for future research are also identified.

## 2. SOCIOECONOMIC FORECASTS FOR INDIANA STATEWIDE TRAVEL DEMAND MODEL

### 2.1 Overview

In the recent development of the socioeconomic forecasts for INDOT's 2035 long-range plan, it was found that the REMI model long-range employment

forecast was extremely pessimistic. Employment did not return to 2007 levels until 2035. This chapter investigates the application of socioeconomic forecasts in regional and state practices and discusses appropriate variables for ISTDM and popular data sources. For providing more accurate inputs to ISTDM, potential adjustment to REMI forecasts and allocation analysis for travel demand model are analyzed.

### 2.2 Literature Review

Socioeconomic forecasts are significant to a regional economic outlook. Choi and Hu (12) conducted a survey of regional socioeconomic forecasts and models used in a variety of Councils of Government (COGs)/ Metropolitan Planning Organization (MPOs) to understand the current practices of developing growth forecasts. It was found that UrbanSim, which is a land use simulation model based on economic theories, was increasingly employed by COGs/MPOs to determine the distribution of population and employment within each county. The specific applications for the surveyed COGs/MPOs are shown in Table 2.1.

In July 2011, new population and employment forecasts for 31 counties in the New York metropolitan region were published by the New York Metropolitan Transportation Council (NYMTC). The forecasts for total employment and total population at subregional and county levels were prepared for 5-year intervals from 2010 to 2040 (13). The employment model is composed of five sets of equations, each consisting of approximately 30 equations, with one set for every subregion. The equations were derived using ordinary least squares (OLS) regression analysis, and give the subregional level employment/wages/income as a function of one or more independent variables, including national and regional measures of economic activity and competitive advantage. The county-level forecast is then disaggregated from the subregional forecasts. The employment model is based on the historical county/subregional employment data by North American Industry Classification System (NAICS) and in con-

TABLE 2.1  
Regional Socioeconomic Forecasts Practices in COGs/MPOs

COG/MPO	State	No. of Counties	Horizon (Years)	No. of Variables	Development of Forecast Process
Houston-Galveston Area Council (H-GAC)	TX	13	30	Population by age/race, households by age/race/size, employment by 7 sectors	A disaggregated simulation cohort-component model with explicit migration module were employed; UrbanSim model was combined with regional travel demand model
Maricopa Association of Governments (MAG)	AZ	1	25	Population, 7 types of employment, 30 additional variables	A new up-to-date software and newer model were considered to replace MAG Socioeconomic Model, in order to reflecting the interrelationships of growth between Maricopa County and surrounding counties
Pima Association of Governments (PAG)	AZ	1	30	Population and employment etc. 17 additional variables.	POPGROUP and HOUSEGROUP forecasts module were utilized to develop county-wide forecasts
Puget Sound Regional Council (PSRC)	DC	4	30–35	103	Employment projection by NAICS was used and DRAM/EMPAL allocation model was replaced with UrbanSim model
San Diego Association of Governments (SANDAG)	CA	1	25–30	Hundreds (regional level); population/employment/ geography by 90 land use categories (subregional level)	Developing a Production, Exchange, and Consumption Allocation System (PECAS) model that directly link to regional econometric forecasting model so that land use constraints are captured by the regional socioeconomic forecasting model.
Southern California Association of Governments (SCAG)	CA	6	30–35	Hundreds (TAZ level)	PECAS and UrbanSim were integrated for the small area forecast
Wasatch Front Regional Council (Salt Lake City MPO) (WFRC)	UT	5	25	Population, households, and employment by three sector	Making forecast based on UrbanSim model. Also, upgrading UrbanSim model to the (Open Platform of Urban Simulation) OPUS is under consideration.

Source: (12).

junction with a U.S. Long Term Trend Forecast by IHS Global Insight (GI) as a national driver. GI's long range forecast is regarded as the best unbiased projection of the national economy, with only a 10% chance that the realized path will lie outside a specified trajectory. The baseline assumes that the national economy will grow smoothly along a full employment path, suffering no major mishaps between 2011 and 2040. The population model is based on the cohort-survival technique (14).

In the case of statewide socioeconomic forecasts, Indiana has used REMI within MCIBAS since 1995. In 2003, one of Arizona's leading economic forecasters, Marshall Vest, prepared a review of REMI for the Arizona Department of Commerce, in order to provide an appraisal of the REMI model before actually employing it for public policy purposes. The Vest study tested REMI by updating the model's national and regional employment forecasts. The economic forecasting service Global InSight (GI) was used to update REMI employment forecasts on both national and regional levels. The GI forecasts, which have a time lag of two or more years and are based on Bureau of Labor Statistics (BLS) data, seemed more reasonable than the pessimistic REMI model forecasts in Arizona's case (15).

Dr. Vest set up a peer review process to assess the REMI model's value for Arizona practice. The peer

review revealed that: (1) REMI is a rich structural model, and there are many policy variables that can be used by the analysts to create long-term projections, but REMI is not suited for short-term forecasts; (2) REMI would be useful as a policy impact tool, but less so as a forecasting model. It wasn't constructed to do forecasting; (3) REMI may be sensitive to the period selected. If a lot of lagged dependent variables are used in the construction of some equations in REMI, and the economy is on the decline, it can pull everything down; (4) Econometric models (e.g., GI) tend to be less detailed than competitive equilibrium models (e.g., REMI). Although they do not necessarily maintain internal consistency among various industrial sectors, econometric models are easily and quickly updated. More importantly, in a dynamic sense, econometric models statistically measure the actual response of industries to changes in the economic environment. Econometric models tend to be more accurate in predicting what is expected to occur in the future, based on past experience (15).

Michigan has been using various versions of the REMI model since 1983 to assess projects for several state and local government agencies. The Southeast Michigan Council of Governments (SEMCOG) in 2007 provided detailed regional forecasts for each year from 2010 through 2035 in 5-year intervals for population, employment, personal income, and households in order

to find ways to restructure the regional economy during the structural economic crisis (16). A seven-county version of the REMI model covering the SEMCOG region was used in their study. Forecasts for each county were developed and summed to the regional forecast totals. They put forward an economic and demographic outlook, as well as two alternative scenarios. One scenario portrayed a more pessimistic outlook for the region, and the other depicted more favorable prospects for growth in specific industries.

In 2008, the Michigan Department of Transportation (MDOT) presented forecasts in its Economic and Demographic Outlook. The long-term economic and demographic forecasts were developed by University of Michigan economists for each of Michigan's counties and for the state as a whole. Correspondingly, an eighty-three county version of the REMI model was customized for MDOT. The county forecasts were summed to the state forecast totals. In addition, another interface model developed by the University of Michigan and MDOT was used to account for the household forecasts at the county level (17).

In agreement with Arizona's work, MDOT believes that the REMI model shouldn't be used "out of the box" for forecasting. The University of Michigan economists re-calibrated the original U.S. forecast based on their own work and had REMI substitute it into their current model. Because REMI is mainly developed for economic impacts analysis, and not for statewide economic forecasts, MDOT had the REMI forecasts modified based on inputs from several demographers and university economists. MDOT uses a Transportation Technical Committee (TTC) as an expert panel to review and, as necessary, adjust inputs to the travel demand models used by MDOT and the MPOs. The TTC includes MDOT technical staff and middle management, representatives of the Metropolitan Planning Organizations (MPOs), representatives of the state regional planning organizations and technical staff for the SEMCOG. Details about Michigan's TTC are given in a later chapter of this report.

## 2.3 Socioeconomic Variable Descriptions

### 2.3.1 General Socioeconomic Variables

In order to provide inputs to the trip generation step in the ISTDm, seven socioeconomic variables are required for both the base year and the forecast year: population, number of households, median household income, number of automobiles per household, retail employment, non-retail employment, and school enrollment.

- **Population:** all the people who live in the same geographic area regardless of race, gender, age and religion.
- **Number of households:** the number of the basic residential unit in which economic production, consumption, inheritance, child rearing, and shelter are organized and carried out.

- **Median household income:** total income in a household that is in the middle rank of all households in a given geographic.
- **Number of automobiles per household:** the number of autos owned by individual household.
- **Retail employment:** employment for the sale of service or goods from a fixed location in individual lots for direct consumption by the purchaser.
- **Non-retail employment:** employment in non-retail jobs.
- **School enrollment:** the population who report being enrolled in a regular school like elementary school, high school, college, university, and professional school.

### 2.3.2 Population Growth Trends

The 2010 U.S. Census data (18) show that the United States grew by 27.3 million people, or a 10-year growth rate of 9.7%. The population of the State of Indiana grew by 403,317, or a growth rate of 6.6% since the 2000 census. Indiana was the 33rd fastest growing state in the nation and remains the 18th most populous state. In comparison, during the same period, Indiana's neighboring states grew at the following 10-year rates: Kentucky 7.4%, Illinois 3.3%, Michigan 0.6%, and Ohio 1.6%. In the 1990s, Indiana was the 27th fastest growing state, with a growth rate of 9.7%, compared to the national rate of 13.2%. (See Figure 2.1.)

According to the 2010 Census, of Indiana's 92 counties, 63 grew faster than the state's rate. Hamilton County, Hendricks County, and Hancock County are growing the fastest in the state, with growth rates of more than 25%.

### 2.3.3 Income and Employment Growth Trends

Per capita personal income is often used to measure economic well-being. Indiana's per capita personal income (\$34,943 in current dollars) ranked 42nd in the nation in 2010 (19), about 86.1% of the national average. Indiana's state employment growth rate was 0.29% between 2010 and the second quarter of 2011. From 1990 to the second quarter in 2011, U.S. employment grew by 19.41%. Indiana employment which suffered from a largest drop across recent two decades and reached the lowest in 2009, and then increased by 11.12% to now. In comparison, employment in Indiana's neighboring states grew at the following rates during 1990–2011: Kentucky 21.54%, Illinois 7.18%, Michigan -0.82%, and Ohio 4.12%. (See Figures 2.2 and 2.3.)

## 2.4 Socioeconomic Forecasts Data Source Identification and Comparison

### 2.4.1 Fundamental Socioeconomic Census and Survey

The base-year data for socioeconomic forecasts data are generated from the following fundamental census and survey sources:

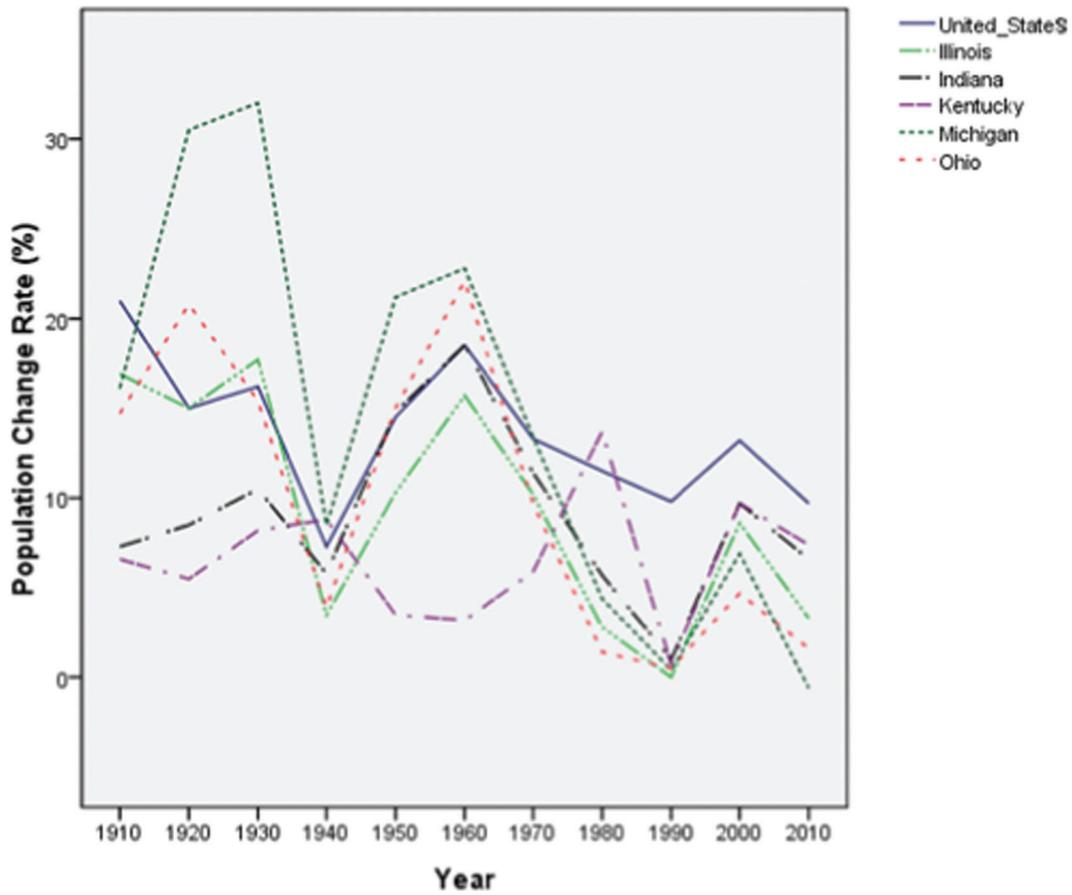


Figure 2.1 Population change rates since 1910. (Data source: (18).)

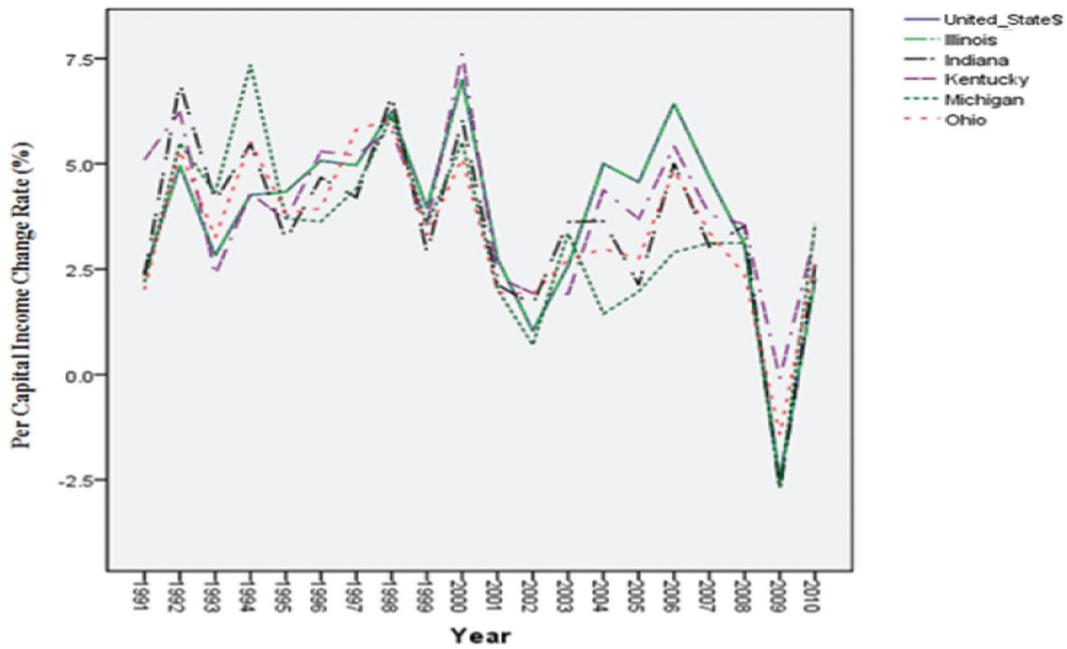


Figure 2.2 Per capita income change rates since 1990. (Data source: (20).)

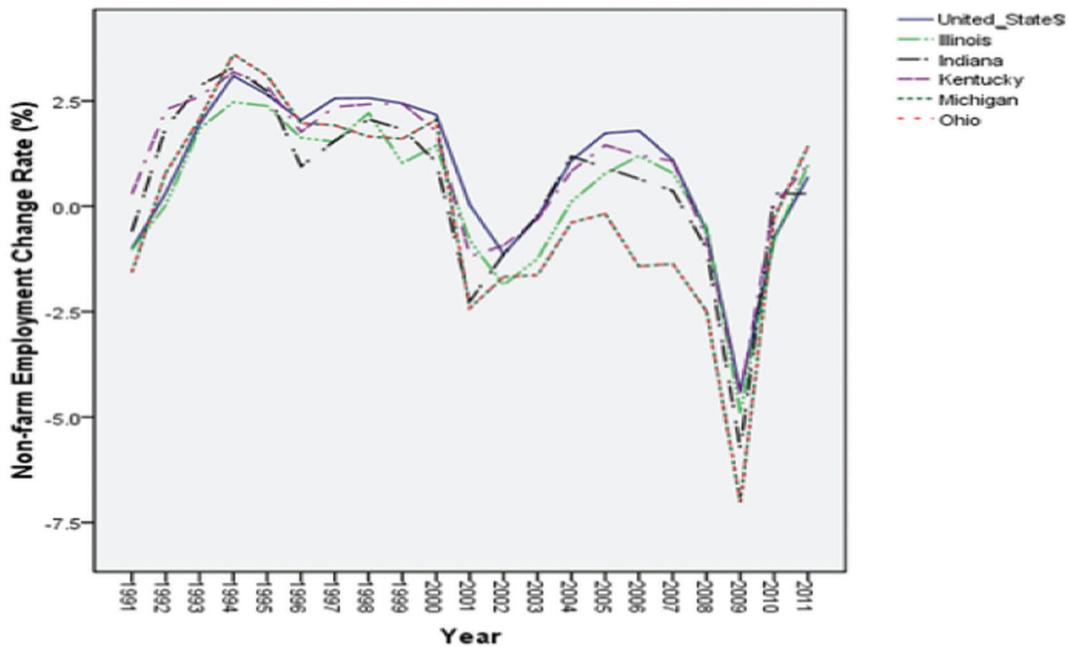


Figure 2.3 Employment change rates since 1990. (Data source: (21).)

**Decennial Census.** The decennial census has been conducted across the country every 10 years, in years ending in “0” since 1790, as required by the U.S. Constitution. Its purpose is to count the population and housing units for the entire United States. The 2010 Census is the latest one and will be the benchmark for the demographic characteristics.

**American Community Survey (ACS).** The ACS (22) is a nationwide survey conducted by the U.S. Census Bureau and designed to provide communities a fresh look at how they are changing. The ACS is released by 1-year, 3-year and 5-year estimates. It plays a role of filling in the gaps between the decennial censuses. All ACS data are survey estimates, because the ACS is conducted via questionnaire from a sample of the population. Most of the questions in the ACS are the same as (or similar to) the Decennial Census long form. It can provide the same socioeconomic data as the Decennial Census. The latest available ACS data products are the 2009 1-year estimates, the 2007–2009 3-year estimates and the 2005–2009 5-year estimates.

**Census Transportation Planning Package (CTPP)**  
**3.4.1.1 IMPLAN.** The CTPP (23) is a set of special tabulations from the Decennial Census demographic surveys designed for transportation planners. It is a primary source of information for developing travel demand models, as well as for analyses that influence transportation policy. It summarizes information by place of residence, by place of work, and for worker flows between home and work. The data is tabulated from answers to the Census long form questionnaire (or now, the ACS) and is aggregated to the TAZ level for

use directly in travel demand models. The CTPP from ACS 2006–2008 is the latest data product.

**Economic Census.** The economic census provides a detailed portrait of the United States’ economy once every five years, from the national to the local level. The Economic Census covers most of the U.S. economy in its basic collection of establishment statistics, based on the North American Industry Classification System (NAICS). The latest one is the 2007 Economic Census.

**National Household Travel Survey (NHTS).** The NHTS is a periodic national survey, to assist transportation planners and policy makers who need comprehensive data on travel and transportation patterns in the United States. The data is collected on daily trips and the survey is released every 5 years. The 2009 is the latest survey collected by FHWA, in coordination with a private firm.

**Quarterly Census of Employment and Wages (QCEW).** The QCEW program, also known as the ES-202 program, is conducted by Bureau of Labor Statistics (BLS) and the State Employment Security Agencies (SESAs). It reports monthly employment and quarterly wage information for workers covered by State unemployment insurance (UI) laws and Federal workers covered by the Unemployment Compensation for Federal Employees (UCFE) program, by 6-digit NAICS industry, available at the county, MSA, state and national levels by industry. It is released 7 months after the end of each quarter. The latest release is in the third quarter of 2010.

#### 2.4.2 Socioeconomic Forecasts Data Source

To provide population forecasts for the ISTDM, Bernardin Lochmueller & Associates, Inc. (24), examined Woods & Poole Economics forecasts (released in April of 2004), Indiana State Data Center forecasts, the REMI forecast for the State of Indiana, projections based on the historical 30-year population growth rate, and projections based on the historical 10-year population growth rate. To provide employment forecasts for the ISTDM, BLA has also examined Woods & Poole Economics forecasts (released in April of 2004), and the REMI forecast for the State of Indiana.

**Woods & Poole Economics forecasts.** Woods & Poole begins with the U.S. Bureau of Economic Analysis employment forecasts for States and metropolitan areas, allocates employment to individual counties, and generates associated demographic information. Woods & Poole county projections are updated annually and utilize county models that take into account specific local conditions based on historical data from 1969 to 2008 (1969 to 2009 for population); all data from 2009 to 2040 (2010 to 2040 for population) is projected. One key aspect of Woods & Poole projections is that the economies of counties are linked together: projected economic conditions in one county are reflected in the projected economic conditions in other counties. County population growth is a function of both projected natural increase and migration due to economic conditions. Although not an indicator of future accuracy, the average absolute percent error for Woods & Poole's 10-year total population projections has been  $\pm 8.3\%$  for counties and  $\pm 4.2\%$  for states. These forecasts are generally based on regression analysis techniques of historical population data without a direct relationship to the economy.

**STATS Indiana.** STATS Indiana is the official digital data center for Indiana, providing critical statistics for the state, counties, cities and towns, townships, regions, metros, census tracts, and more. Data are available from federal, state, local, and private agencies. Besides the previously mentioned state departments, data are available from the Census, Bureau of Economic Analysis (BEA), Bureau of Labor Statistics (BLS), National Center for Education Statistics (NCES), National Science Foundation (NSF), National Center for Health Statistics (NCHS), U.S. Patent and Trademark Office (USPTO), U.S. Courts, Council for Community and Economic Research (ACCRA), The Conference Board, MoneyTree.com, RealityTrac.com, and Economy.com. With this vast compilation of data sources, most employment, population, vehicle, and household data are available. These forecasts are generally based on regression analysis techniques of historical population data without a direct relationship to the economy.

**Regional Economic Models, Inc. (REMI).** The software developed by REMI is currently used by INDOT to model the short-term and long-term effects that local

economic and transportation impacts have on the regional economy. REMI combines "input-output," "general equilibrium," "econometric," and "economic geography" modeling approaches. Data for the model primarily comes from the Bureau of Economic Analysis, Bureau of Labor Statistics, QCEW, and various Census programs with a 2-year data lag. The REMI model is highly complex, allowing for the interactions between industries, and then compounding these changes annually, to result in a final forecast. To run this rather complex model, technical expertise is essential. If technical staff is unavailable, the use of the software for local applications can be outsourced to the REMI Corporation. The software has a base purchase price of \$53,000 and another \$10,000 annually to update the database. Such costs make use of this model by small and medium-sized MPOs impractical.

**CEMR-IBRC model.** Another promising data source is the Center for Econometric Model Research (CEMR) (25), which is affiliated with the Indiana Business Research Center (IBRC). The CEMR-IBRC model forecasts can be used to adjust REMI employment forecasts for the State of Indiana, because it is an econometrics model built upon the knowledge of local economists, and tends to be more accurate as a predictive model (15). CEMR-IBRC model consists of the Indiana Model of the U.S. (IMUS), the Indiana Model of Indiana (IMI), and the Indiana Metropolitan Statistical Areas (MSAs) Forecast Model. In addition to short-run forecasts, CEMR also constructs long-range projections for both the United States and Indiana. The forecasts are produced on a semi-annual basis with a horizon of 20 years. There are no separate models for long-range projections—the IMUS and IMI models are simply extended out to the longer horizon. For the Indiana economy, in addition to producing a baseline forecast, two alternative projections (a high and low scenario) are produced as well. These alternatives are generated by making moderate adjustments to exogenous variables within the IMI model. The short-run forecasts are issued quarterly for the U.S. and for Indiana. These predict a range of annual and quarterly increments for three full years beyond the current year. The long-run forecasts for the U.S. and for Indiana are issued each February and August, forecasting employment and personal income annually for more than 20 years into the future. The State Utility Forecasting Group (SUFG) at Purdue University is responsible for projecting consumption of electric utilities across the state of Indiana. The SUFG uses the CEMR's statewide model, consisting of macroeconomic and demographic projections, as the basis for electric consumption projections. Annual subscription fees range from \$1,500 to \$4,000.

#### 2.4.3 Data Sources Evaluation and Comparison

The recent REMI model forecast for Michigan was based on 2008 data, which started the forecasts in a

direction more pessimistic than would have occurred if the 2009 data (not available) had been included. Similar conclusions can be drawn from recent REMI runs for INDOT. Version 1.1.5 (build 1965) showed total employment dropping from its 2007 peak and not returning to that level until 2035 (see Figure 2.4). The new model—version 1.2.4 (build 2199)—now shows employment recovering by 2015 (see Figure 2.5). The newer REMI version provides a much more realistic forecast for purposes of long-range planning. Version 1.2.4 shows approximately 4.35 million employment in Indiana in 2035, which is reasonable and close to the results of 4.4 million from an older 2006 REMI forecast (REMI 9.5) and update to the 2035 statewide travel demand model.

These plots revealed the changes between Version 1.1 and Version 1.2. The economic data, including employment, wages, personal income and earnings, and demographic data like population and labor force, have been updated up to 2008 at the national, state and county levels. Also, new estimates of trade flow parameters are used in the new model version. Also, the base (growth factor) of state government expenditures has been modified to be based on the state government demand in the last history year instead of the current year's state government spending. Moreover, an alternative model option has been added to allow users to change the government spending response to be based on population only, instead of a combination of population and GDP. In addition, a scenario detailing how to conduct a natural disaster analysis and a new policy variable of farm output have been included in the v1.2 REMI model (*REMI, 2010*) (28). It appears the v1.2 REMI model could revise the

Indiana control forecast to provide this more reasonable forecast along with the periodic version update of data sources/model structure, or both.

Even though the REMI forecasting results can be made more reasonable by updating the historical data base for recent years, the REMI model is not designed for long-term forecasting (Vest, 2003) (15). Because it is developed by in-state economists at Indiana University (IU), the CEMR-IBRC model can be expected to reflect a more comprehensive understanding of the economy in Indiana than the REMI model. A series of comparison plots of employment, population, and personal income forecasts produced by REMI and CEMR-IBRC are shown in Figures 2.6–2.8. These plots were done before the release of CEMR's August 2011 forecasts, which also reflected the more positive recent data:

Compared to the February [2011] outlook, our current forecast for the Indiana Economy has turned more optimistic in regards to employment and annual growth rate of personal income. (CEMR-IBRC 2011.) (29)

For nonfarm employment, REMI forecasts are proportionally higher than IU model forecasts across the whole analysis period. It is probably due to the different definitions of employment in REMI model data source and CEMR-IBRC data source. REMI uses BEA series data as one of sources of employment and wage and salary data. BEA employment is defined as full and part-time employment, which includes self-employed, domestic, unpaid family workers, farm workers, and the military employment. And these data are of annual frequency and are reported with a lag of



Figure 2.4 REMI baseline forecasts of total employment for Indiana state. (Data source: (26).)

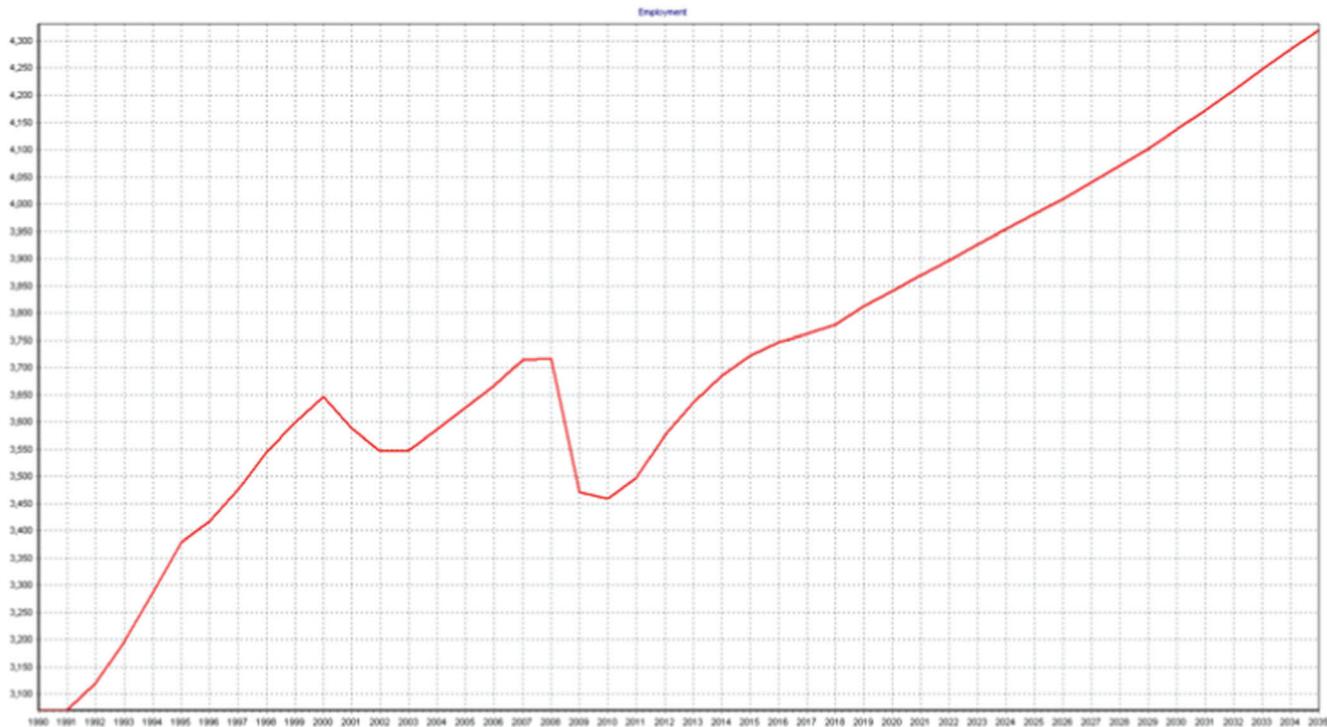


Figure 2.5 REMI baseline forecasts of total employment for Indiana state. (Data source: (27).)

two or more years. CEMR-IBRC model mainly used BEA Regional Economic Information System (REIS) data. REIS data cover employment and income by industrial sector at a county level and released with a 2-year lag. Self-employed data is commonly not included.

For Indiana population and total personal income, the plots of REMI forecasts overlap with those of CEMR-IBRC forecasts before 2009. So they are probably based on similar historical data set. After 2009, however, the REMI forecasts show greater

growth than the IU forecasts. According to Dr. George Fulton, long-term forecasts attempt to capture economic trends, but cannot predict business cycles or major one-time events. The general trends of Indiana employment, population and total personal income curves are consistent in the REMI and CEMR-IBRC forecasts.

In Table 2.2 we find that neither REMI forecasts nor the CEMR-IBRC model can derive household data for ISTDM directly. Only in combination with Woods &

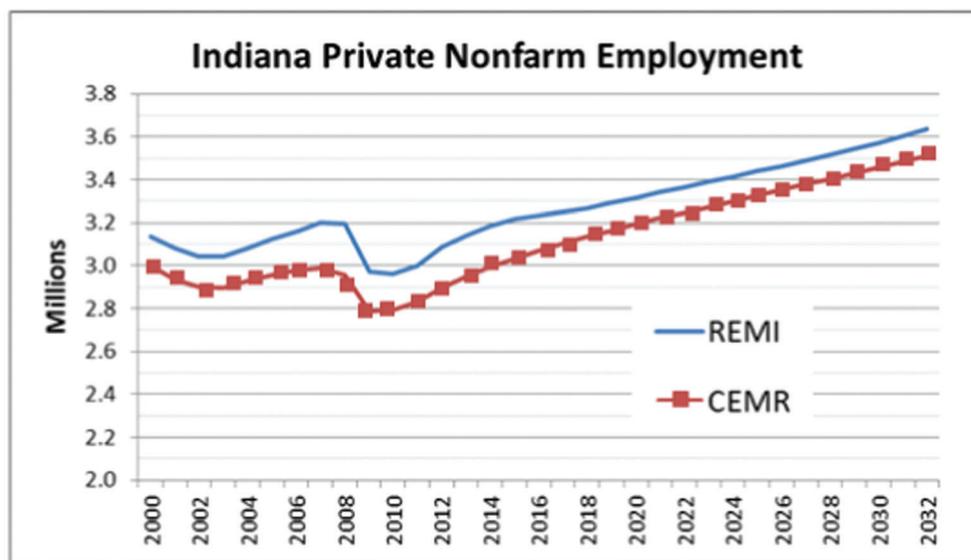


Figure 2.6 Comparison of private non-farm employment forecasts in Indiana state. (Source: (29).)

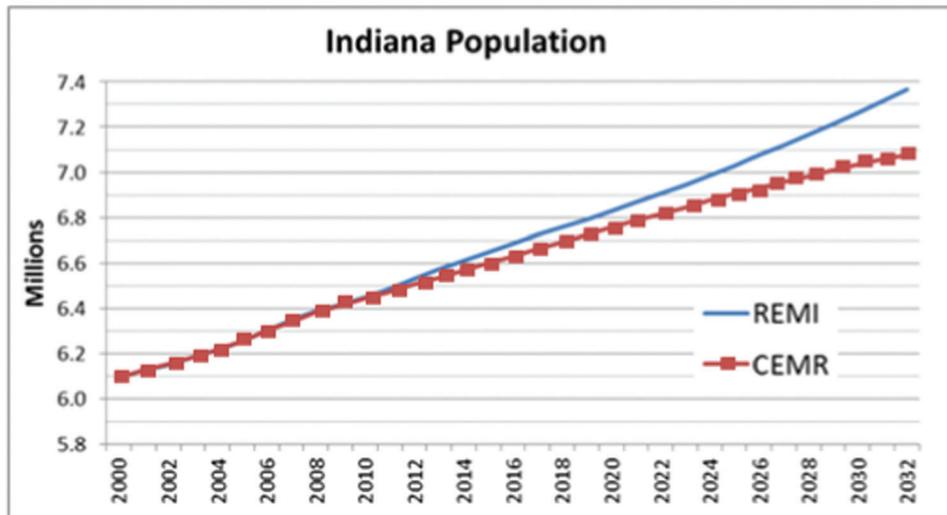


Figure 2.7 Comparison of Indiana population. (Source: (29).)

Poole or STATS Indiana, or both, can the forecasts meet the input requirements of the ISTDM.

### 2.5 Framework of Zonal Socioeconomic Forecasts for the ISTDM

**A. Population Forecast.** For deriving forecast zonal population, the horizon year in which ISTDM developers are interested should be defined. Then, reliable and economical data sources for the forecasts are identified. The next step is to establish appropriate combining strategies based on current available data sources to obtain total numbers for population for each county for both base year and projection years. Finally, the control totals are allocated to TAZ-level forecasts in each county by building a regression model. The process can be illustrated by Figure 2.9.

**B. Employment Forecast.** In Figure 2.10, the first four steps for deriving forecast zonal employment are similar to those for the zonal population forecasts: defining expected years, finding appropriate data sources, determining control totals and allocating to TAZ level. The difference is in the last step: the TAZ level employment forecasts still need to be broken down by different industrial sectors.

### 2.6 Strategies for Obtaining County Control Totals

#### 2.6.1 Population and Employment

In 2004, the BLA consultants came up with a strategy for population and employment forecasts in which they chose REMI forecasts as the baseline for individual counties. This is because the REMI forecasts fall between the Woods & Poole forecasts and STATS

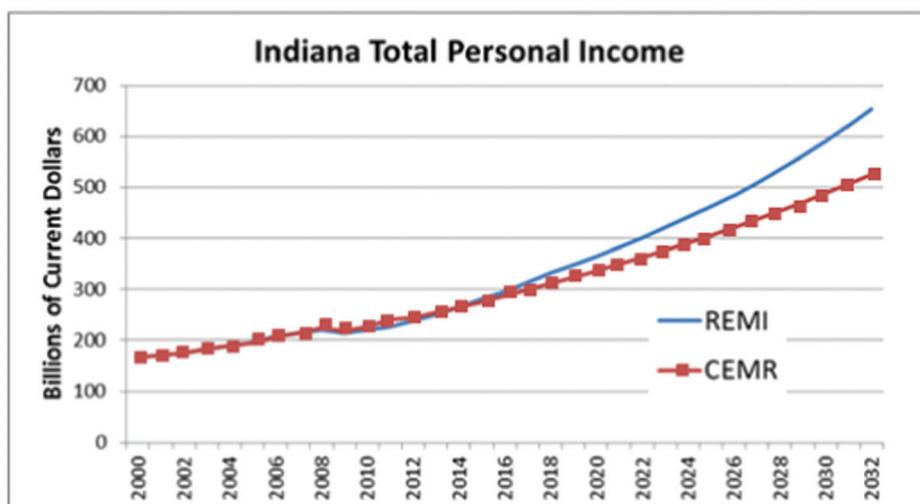


Figure 2.8 Comparison of Indiana total personal income. (Source: (29).)

TABLE 2.2  
Features of Current Socioeconomic Forecasts Data Source for INDOT

		Current socioeconomic forecasts data source used by INDOT			Possible alternative data source
		Woods & Poole	STATS Indiana	REMI model	CEMR-IBRC model (customized package of STATS Indiana)
Lowest geographic level		County	County	State	County
Updating schedule		Annually	Annually	Annually	Semi-annually
User-access costs		\$345/Edition	FREE	\$53,000 +\$10,000/y	\$1,500~4,000/y
Available socioeconomic variables	Population		★	★	
	Number of households	★	★		
	Median household income	★	★		
	Automobiles per household		★		
	Retail employment	★		★	★
	Non-retail employment	★		★	★
	School enrollment	★	★		

Source: (30).

★= Variable is available in data source.

Indiana forecasts (24). Using 2011 Woods & Poole forecasts, REMI PI+ Indiana v1.2.4 (build 2199) forecasts, and STATS Indiana forecasts (which are currently CEMR-IBRC model forecasts), we produced comparison plots of Indiana total population and total employment. (See Figures 2.11 and 2.12.) In the plots, we can see that, based on current data sources, statewide REMI forecasts are close to Woods & Poole forecasts for both population and employment. STATS Indiana population forecasts (Figure 2.11) seem more pessimistic than the other forecasts. The STATS Indiana employment forecast is lower than the other forecasts in Figure 2.12 at an approximately constant value, which reflects the fact that the Woods &

Poole and REMI models use a different definition of *employment*. STATS Indiana projection (CEMR-IBRC model) follows the Bureau of Labor Statistics (BLS) definition, which does not include self-employed or agricultural employment. Woods & Poole and REMI use BEA data, which reflect the actual number of jobs, not the number of persons employed. Woods & Poole and REMI also use similar econometric models and therefore produce similar, and higher, trends.

Because of their consistency with Woods & Poole projections over the next 30 years, REMI forecasts can be used as the benchmark for statewide control totals. Because Woods & Poole data are provided at the county level, we could divide Woods & Poole county

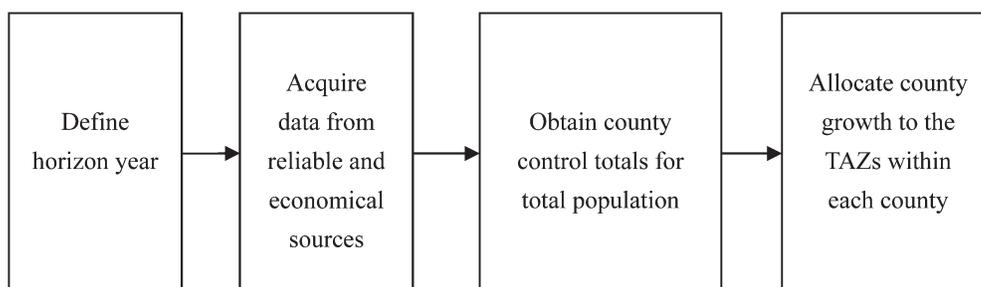


Figure 2.9 Process of developing zonal population forecasts.

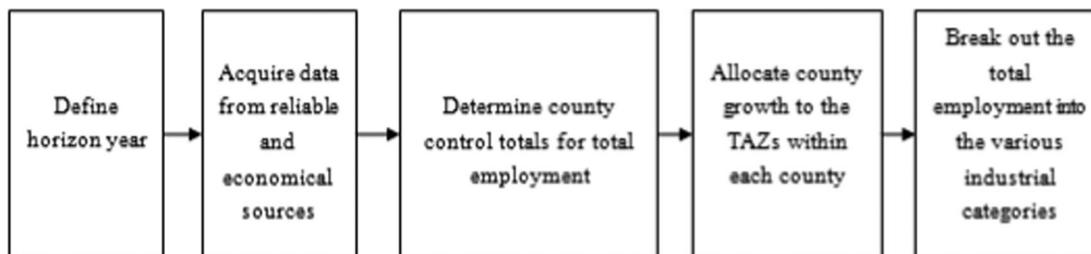


Figure 2.10 Process of developing zonal employment forecasts.

data by statewide Woods & Poole forecasts to produce county proportions. These proportions could be used to allocate REMI statewide forecasts to derive county control totals. In addition, STATS Indiana projections based on the CEMR-IBRC model could be more insightful in revealing the state and regional economy, because the model is being applied by local (Indiana) economists.

The Indiana Business Research Center (which now manages CEMR) has developed a very promising approach to estimate *county* employment for all NAICS industries down to the 6-digit level. The research did not attempt to do this for subcounty areas such as TAZs, and in fact is unlikely to do so, given inherent limitations of the source data. The IBRC method has yielded substantially more accurate estimates than those generated by Moody's Economy.com, and at finer levels of industry specificity (Moody's estimates go only to 4-digit NAICS industries). Additional work is underway at IBRC to estimate county employment by detailed occupation.

### 2.6.2 Total Number of Households

The number of households at the county level by eleven income groups can be obtained from the 2011 Woods & Poole forecast for years 1970 through 2040.

Also, projected state and county level household data can be extracted from the STATS Indiana website, based on 2000 and 1990 Census data. The household data from the 2010 Census demographic profile is still being compiled as this is written.

### 2.6.3 Median Household Income

Household income can be used as input to the trip production step in the ISTDM Only monetary income is reported by the Census Bureau, while total income, including some types of nonmonetary income, are counted by Woods & Poole. As a result, Woods & Poole income tends to be higher than income data from the Census Bureau. Woods & Poole projections give only the mean household income, but the Census data provide a ratio of median to mean income. If median household income is desired, the Woods & Poole mean household income can be multiplied by the ratio data to estimate median household income.

### 2.6.4 Automobiles per Household

The number of vehicles in a household in past years can be found through the STATS Indiana database and extracted from the Census 2000 summary files. BLA and

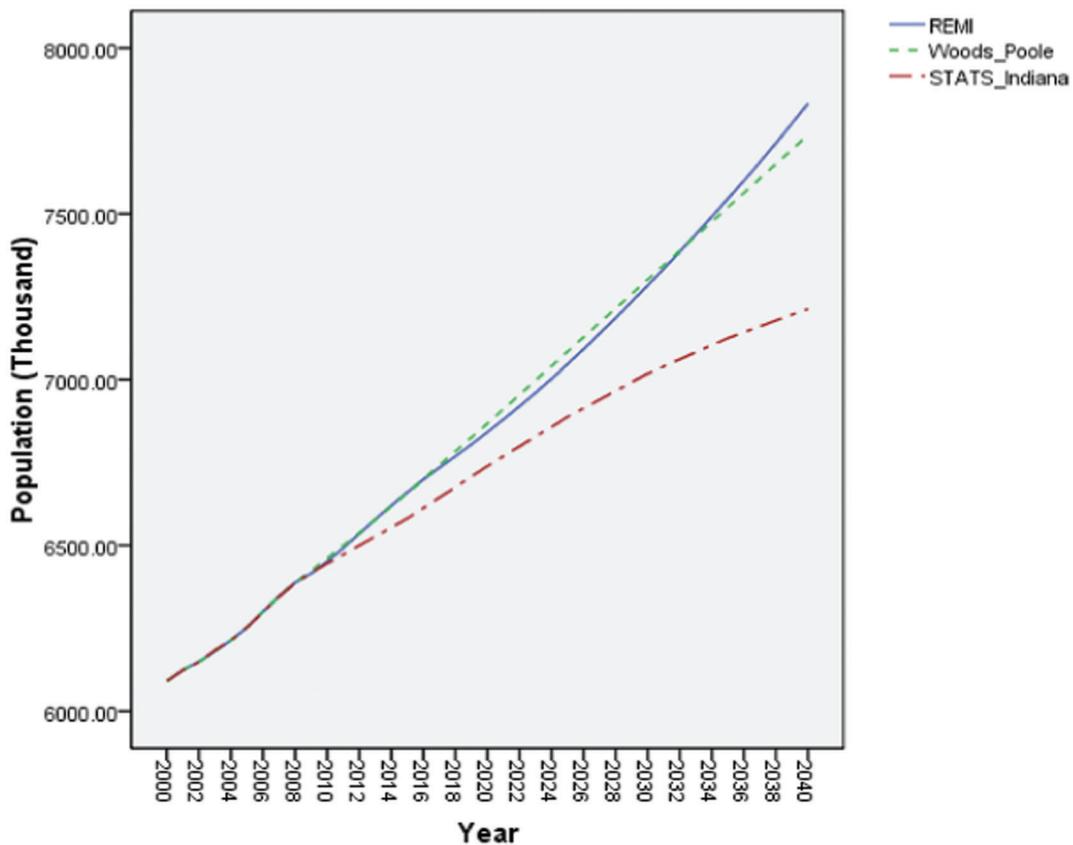


Figure 2.11 Indiana total population forecast (2000–2040). (Source: (9,27,29,31).)

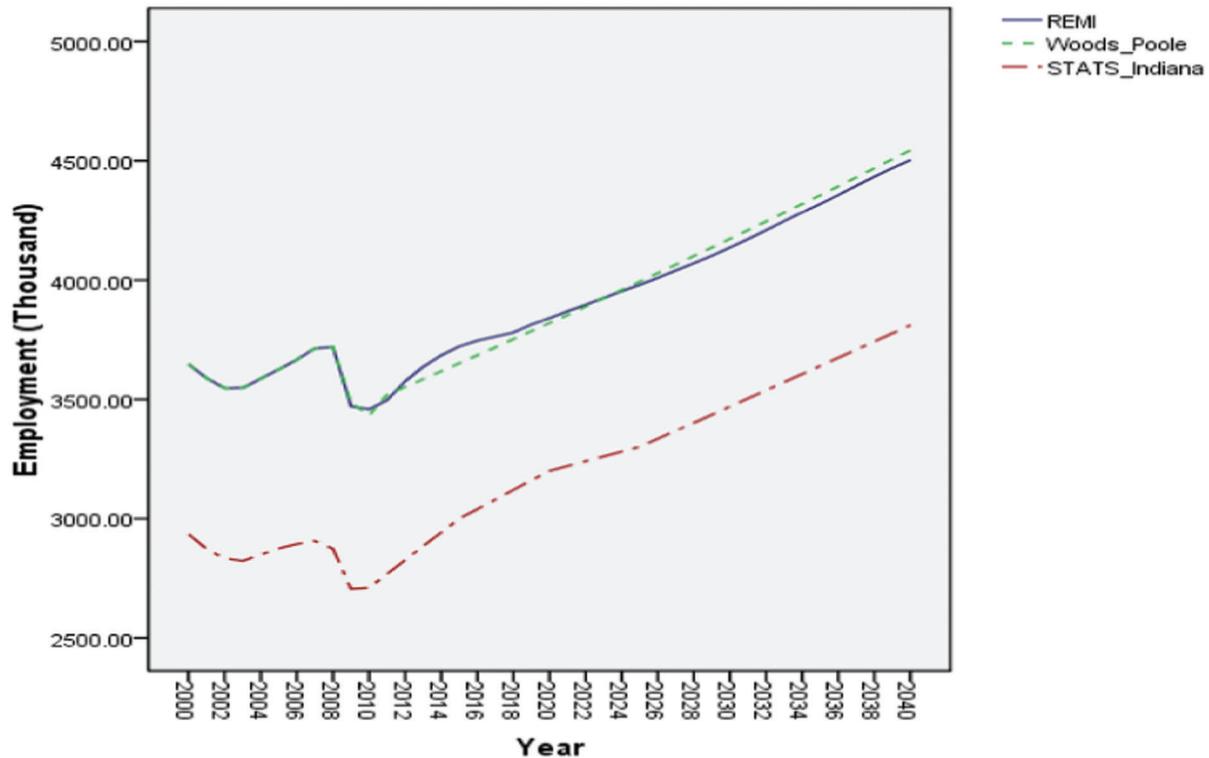


Figure 2.12 Indiana total employment forecast (2000–2040). (Source: (9,27,29,31).)

others have confirmed that the number of automobiles per household has a strong correlation with household income.

### 2.6.5 School Enrollment

School enrollment data can be collected from the Indiana Department of Education (IDOE) website. Students attending public and non-public schools in the State of Indiana from “Pre-School” to “Grade 12+/ Adult” can be found by school name. According to the location of each school, the tabulated school data can be geocoded and assigned to the zonal level.

## 2.7 Methods for County Growth Disaggregation

State DOTs usually obtain statewide forecasts as control totals and then break them down to county and TAZ level to drive their statewide travel demand models. Even though MPOs can supply detailed forecasts for the TAZs in their metropolitan models, they often follow the statewide control total and arrive at TAZ level inputs by using their own methods. For example, SEMCOG in the Detroit area has adopted UrbanSim software, which takes regional control totals and detailed land use data to allocate activity to the parcel level, which is then aggregated to the TAZ level. These TAZ totals are shared with the affected communities in the Detroit area and adjusted as appropriate.

Population and employment are allocated among the TAZs in each county using a regression model. The

largest TAZ is similar to a township in size. To convert REMI’s statewide forecasts to the TAZ level, INDOT uses Woods & Poole county-level forecasts, geocoded point files from InfoUSA, and consulting help from Bernardin, Lochmueller & Associates (BLA). BLA used a regression model to estimate the zonal population and employment in 2000 and 2030. The independent variables included total population, total household, population density, aggregate personal income, presence of airport, presence of hospital, university enrollment, travel time to nearest city center, travel time to nearest major arterial, travel time to nearest freeway, accessibility to intermodal freight facilities, accessibility to households, accessibility to population, accessibility to university enrollment, and accessibility to wealth (by place of residence). The regression also included several interaction terms. The estimated change in employment or population from the regression model was expressed as a change in the zonal share of the county total employment/population (2).

## 2.8 Conclusion

This chapter examined the possible socioeconomic data sources to drive the ISTDm. Possible and potential data forecasts are evaluated and compared in terms of seven essential input variables in both quantity and quality. Updated forecasts of the latest REMI version appear reasonable and consistent with Woods & Poole projections in the long-term horizon

years. The consistency between the REMI and Woods & Poole forecasts gives them added credibility. The forecasts of STATS Indiana projection model produced by IU's Center for Econometric Model Research (CEMR) were lower than REMI's and Woods & Poole's. Because it is developed by in-state economists at Indiana University, the CEMR-IBRC model is likely to reflect greater insight and a more comprehensive understanding of the Indiana statewide and regional economy than does the REMI model.

A general process of developing zonal socioeconomic forecasts was discussed. REMI statewide forecasts can be converted into county-level values based on county projections like Woods & Poole and CEMR-IBRC forecasts. Subsequently, a disaggregation regression method developed by BLA consultants can be used to derive population and employment forecasts at the zonal level for input to the ISTD.

### 3. ECONOMIC IMPACT MODELS TO ASSESS TRANSPORTATION IMPROVEMENTS

#### 3.1 Overview

The Indiana Long-Range Transportation Plan leads to a series of transportation projects to enhance state economic competitiveness, productivity, and efficiency. In order to better assess, score and prioritize projects in the Long Range Planning Annual Project Development Process, economic impact evaluation plays a vital role. The REMI model is integrated with MCIBAS to form a hybrid modeling system with which INDOT can assess the impacts of major corridor improvements. INDOT has used REMI successfully for some cases, paying a substantial license and maintenance fee that entitles it to technical assistance and upgrades. However, it is reasonable to explore alternatives that could possibly shed light on REMI's capabilities and limitations. A test of REMI and other models in a variety of situations could give INDOT insight into the application of REMI to future projects and plans. Several promising alternative models are discussed and compared in this chapter.

#### 3.2 Economic Impacts Terms and Concepts

##### 3.2.1 Concepts of Economic Impacts

Besides the economic impacts associate with transportation infrastructure construction activities, economic impacts resulting from transportation improvements are generally classified in the literature (32) as follows:

##### 1. Direct Impacts (Primary Impacts)

Direct Impacts are the direct consequences of a transportation improvement. Changes in travel time, safety, or vehicle operating costs to travelers and non-travelers are converted to cost savings. For example, a reduction in average travel time creates a direct cost savings for a manufacturer that is shipping parts to an assembly plant. A reduction in vehicle operating costs equates to lower out-of-pocket expense for households

and businesses. Direct economic impacts also include the temporary effects associated with construction, such as the employment of labor and purchasing of goods and services during the project.

##### 2. Indirect and Induced Impacts (Secondary Impacts)

Direct benefits to the businesses and residents of a region could stimulate additional activities in the regional and statewide economies, which lead to both indirect and induced impacts. The sum of indirect and induced economic impacts is referred to as secondary impacts, or multiplier effects. The concept is that a dollar in direct benefits ripples through the regional economy and multiplies the original direct effect. Thus, the economic multiplier is the ratio of total benefits to direct benefits (*II*).

- a. **Indirect economic impacts** are generated by the increased economic activities of companies that benefited from the direct economic impacts, like purchasing additional intermediate goods and services. For example, a manufacturer that benefits from a reduction in travel time may use some of its cost savings to purchase more inputs from its suppliers. The increased activity of the supplier is an indirect economic impact.
- b. **Induced economic impacts** are created by the further expenditures due to additional worker income. For example, businesses experiencing direct and indirect impacts will hire more workers or raise salaries. When additional income is spent at local retail and service businesses, it generates induced impacts.

##### 3. Tertiary Impacts

Productivity resulting from transportation efficiency can generate economic growth in the region as well as enhance regional competitiveness, and in the process, stimulate further rounds of economic growth, which is called tertiary impacts.

Also, to easily distinguish among impacts, classifications can be defined as (3):

- a. **User Impacts**, which refer to all the travel time cost savings, vehicle operating cost savings, and safety cost savings realized by travelers, while the effects on non-travelers are not counted.
- b. **Economic Benefits**, which are the benefits that result from user impacts on the economy. It is important to note that economic impacts include only money flows and do not necessarily cover all aspects of benefits that can affect the people's life. Business productivity benefits and tourism benefits are often categorized in economic benefits.
- c. **Total Societal benefits**, which include both income benefits to Indiana residents and the equivalent value of additional quality of life benefits that do not affect incomes, such as noise impacts, air quality impacts and environmental impacts.

##### 3.2.2 Indices of Economic Impacts

A variety of indicators are used to measure the economic impacts. The most commonly used indicators are described below.

- **Wages** are the payments received by workers in exchange for their labor. It is paid depending on time worked, which is contrary to salaries paid on a regular period basis to employees.
- **Employment** is the number of jobs held in a region within a given time period. Along with wages or personal income, this measurement is the most commonly used and easily understood by the public. Along with wages or personal income, employment is a good indicator of benefits and welfare received by local residents.
- **Output** indicates all business sales of goods or services produced in a given time period. All of the raw materials, intermediary inputs, and final products are counted in this measure.
- **Gross Regional Product (GRP)** is the value of all goods and services produced within a region in a given period. This measurement can effectively measure the change in a regional economy.
- **Value Added** is the difference between the sale price and the production cost of a product. It is often used to measure the revenue of companies and factories.

### 3.3 State DOT Approach to Estimating Economic Benefits

After reviewing project reports in the literature, selected state practices for estimating economic benefits from transportation improvement were summarized in Table 3.1.

### 3.4 Economic Impact Models

#### 3.4.1 Input-Output Models

Input-output models can capture the inter-industry linkages of an economy, which lead to wide usage in the economic impact analysis of transportation projects. An input-output model is capable of describing how many units of input various industrial sectors require from all industries to produce a unit of output within a certain area. Given a set of direct impacts of projects, indirect impacts and induced impacts could be estimated by the model. Common commercially available I/O models include IMPLAN and Regional Input-Output Modeling System (RIMS II) (42).

Some limitations may restrict the applications of I-O models. First of all, the models are static economic models. Long-term economic impacts of the transportation investments are only partially accounted for by an I-O model. Except for business expansion impacts and attraction impacts changing over time, direct user impacts and secondary impacts are addressed by the model. These impacts are necessary components of overall economic activities (42). Moreover, it may be difficult to develop localized input-output charts, because the inter-industry relationship from a national forecast is seldom applicable to smaller analysis levels (44,45). In addition, many of the I-O models in use today were developed several years ago. Older models may not reflect up-to-date inter-industry relationships

and can lead to inaccurate results when applied to current projects (4). Furthermore, an I-O model forms the basis of an economic multiplier approach. The economic multiplier approach can obtain the full economic impacts associated with a transportation project, which include business expansion impacts, attraction impacts and tourism impacts. For an I-O model, however, only primary impacts, partial secondary impacts, and none of the tertiary impacts that result from given expenditures can be produced (6). Even though an I-O model is typically not a good stand-alone assessment method for a transportation project, when combined with other methods or approaches such as TREDIS, it could be quite useful (46).

**3.4.1.1 IMPLAN.** The IMPLAN model is a classic I-O economic impact model produced by Minnesota IMPLAN Group, Inc., since 1985. The software is designed mainly to retrieve data, develop the model and analyze impacts. The database includes six main components: (1) employment, (2) value-added, (3) output, (4) institutional demand, (5) inter-institutional transfers, and (6) national structural matrices. These data are derived primarily from the Bureau of Economic Analysis, the Bureau of Labor Statistics, U.S. Census, the Department of Agriculture, and the U.S. Geological Survey, which cover 21 economic and demographic variables for 528 industrial sectors for each of the 3000 counties in the United States. Along with customized databases, users can build I-O models for given geographical areas to estimate the impacts of economic changes in the states, regions, counties, or communities. The user can also modify the trade data and inter-industry relationships in a variety of ways. A variety of multiplier tables, along with economic reports can be produced by IMPLAN. Of particular interest, users can create as many regional models as desired by aggregating counties from the given county-level database.

#### 3.4.2 Dynamic Economic Models

Dynamic economic models are comprehensive economic impact analysis models, because they can account for changes over time, which overcomes the shortcoming of stand-alone I-O models. A typical dynamic economic model forecasts the effects of future changes in business costs, prices, wages, taxes, productivity, and other aspects of business competitiveness, as well as shifts in population, employment, and housing values. Due to its dynamic nature and its ability to account for productivity changes over a 20- to 30-year planning horizon, these models are often preferred for long-range planning (43,47). The representative dynamic models include REMI model, Regional Dynamics (ReDyn) model and Regional Economic Impact Model for Highway Systems (REIMHS).

However, dynamic models rarely predict impacts below the county level, because much of the data used to construct the models is aggregated to the county-level.

TABLE 3.1  
Selected State Practice in Economic Impacts Estimation of Transportation Projects

Year	Name of Project	Source of Project	Prepared by	Summary of Conclusions	Application of the Work
1990	Measuring Economic Development Benefits for Highway Decision-making: The Wisconsin Case	Wisconsin DOT	Economic Development Research Group, Inc.	This study is the first application of the REMI model for transportation projects. REMI model was used to relate changes in business costs of truck shipments to competitive cost of doing business. A three-step process was used to estimate the trucking-related benefits: (1) Conducting a series of surveys to profile truck shipping patterns and current truck reliance on highways; (2) Estimating the business cost savings of proposed highway improvements, based on truck shipping patterns and the cost structure of different types of businesses; (3) Estimating impacts of these cost savings on business expansion rates. Additionally, an expert panel consists of regional economists was convened to estimate the highway project impacts on new industry attraction to the state and affected corridor.	The results helped recognize that the economic impact of a new highway can go beyond the travel cost savings to existing industries and travel patterns. Additional traffic and business activity could be also attracted to a region when a project expands markets and enables new delivery patterns that supports supply chains or opens up new tourism venues. A later Wisconsin study determined that, although using REMI PI to model just travel cost savings for existing travel patterns may have limitations, the use of expert panels may not be the ideal solution for estimating additional business attractions, because personal expectations can over-estimate actual results.
1995	Major Corridor Investment-Benefit Analysis System	Indiana DOT	Cambridge Systematics, Inc., & Economic Development Research Group, Inc.	MCIBAS consists of a traffic impact simulation model, a user benefit-cost analysis processor and an integrated economic impact analysis system. It provides further explanation regarding the economic analysis component, which is designed to assist INDOT in evaluating effects on economy of the state and sub-regions.	MCIBAS was developed to be used for multiple highway investment projects.
2003	Macroeconomic Impacts of the Florida Department of Transportation Work Program	Florida DOT	Cambridge Systematics, Inc.	The analysis showed a very strong connection between transportation investments and key macroeconomic benefits, including income for Florida residents, employment, and the value of goods and services produced in the state. The analysis approach focused on a combination of the Highway Economic Requirements System (HERS) model and the REMI model. The estimates of direct business travel benefits generated by the HERS model were translated into reductions in the cost of doing business and input into REMI to estimate macroeconomic impacts. The user benefits then are translated into inputs to the REMI model to determine macroeconomic impacts of the 5-year program and resource plan.	This study is an analysis of the macroeconomic effects of program-level transportation investments at both the state and district level. The macroeconomic model will be applied at the state and district level and be available for future analysis. The REMI model used in this study is a statewide model. The HERS model was used to estimate three types of direct highway user benefits. A model similar to HERS is used for bridges to capture the benefits of bridge investments—the National Bridge Investment Analysis System (NBIAS).

TABLE 3.1  
(Continued)

Year	Name of Project	Source of Project	Prepared by	Summary of Conclusions	Application of the Work
2004	Identification and Development of User Requirements to Support Robust Corridor Investment Models	Missouri DOT	University of Missouri-Columbia	This study quantifies the multiple impacts (monetary and non-monetary) of transportation investments in order to better inform its decision-making process, and thus make the best use of transportation resources. Missouri Department of Transportation (MoDOT) had considered adopting one of the generally available economic impact models (REMI, RIMSII, or IMPLAN) to support transportation planning, but they determined that these models did not generate the kind of information that was needed. In order to do this, the project employed three strategies: (1) utilizing an advisory panel of highway corridor stakeholders to develop a set of indicators of values and needs with respect to transportation infrastructure, (2) exploring the use of remote sensing and GIS to measure those indicators, and (3) building and test-driving a framework for decision making that includes the necessary range of attributes to satisfy selected indicators.	An Advisory Panel of transportation stakeholders is useful by providing information that was processed into a list of measurable indicators of the nature of the impacts. IMPLAN is recommended as the tool for MoDOT to use to assess the economic impacts of transportation investments, because of its flexibility. High-resolution satellite remote sensing data can provide useful information to quantify indicators, and a methodology was developed to identify commercial and industrial origins and destinations. The combination of economics, statistics, and GIS led to a consideration and demonstration of the utility of GIS to organize data for use with the hedonic statistical method.
2005	Montana Highway Reconfiguration Study	Montana DOT	Cambridge Systematics, Inc.	The study examined the economic impact of reconfiguring the state's major two-lane highways. The study developed Montana's Highway Economic Analysis Tool (HEAT), a GIS-based system that added detailed commodity flow data and an improved version of the Business Attraction Module to account for economic consequences of highway projects changing access to airports, intermodal rail freight facilities and international border crossings, as well as labor and truck delivery markets.	The Business Attraction Module in HEAT, which estimates the direct employment benefits within counties by many industrial sectors owing to improvements in accessibility by highways, was originally developed for Indiana's MCIBAS.
2006	Assessing the Economic Impacts of Transportation Improvement Projects	Utah DOT	Brigham Young University	Based on the findings of a literature search, survey summaries, model evaluations, and outcomes of the steering committee meetings, four approaches are recommended as alternatives to meet the needs for project selection: benefit-cost analysis, economic development analysis, project scoring systems, and a combination of approaches. A steering committee has recommended that a two-tier project prioritization process be implemented for all projects with a total cost of \$5 million or greater. This two-tier type of analysis includes key components of both benefit/cost analysis and project scoring processes.	A summary of evaluation models of REMI, IMPLAN, RIMS-II, HEAT, HERS-ST, STEAM was displayed in a table. REMI was finally used for economic impact forecasting in the study. An instructive steering committee was created to gather expectations of transportation professionals and decision makers regarding economic evaluation criteria.

TABLE 3.1  
(Continued)

Year	Name of Project	Source of Project	Prepared by	Summary of Conclusions	Application of the Work
2006	Early Stage Benefit Cost Analysis for Estimating Economic Impacts	Kentucky Transportation Cabinet	University of Kentucky	The study reviewed various software packages and other methods in use for estimating the economic impacts of proposed transportation projects. It was determined that only the TREDIS model or the TranSight model could potentially meet Kentucky's needs as defined in the project. Both the TREDIS model and the TranSight model are comparable in their economic forecasting abilities. They are also similar in that both require the input of data from a travel demand model.	The TREDIS model appears to calculate economic benefits for a wider range of transportation projects, mostly the smaller scale types such as intersection reconstruction. The REMI TranSight model will be more economical to acquire and run over the long term and has a longer list of clients.
2007	Economic Benefits of the Michigan Department of Transportation's 2007-2011 Highway Program	Michigan DOT	University of Michigan & Economic Development Research Group, Inc.	This study conducted an economic benefit analysis of the Michigan Department of Transportation's current Five-Year Highway Program, which can make substantial investments on the preservation, maintenance, and enhancement of the state's road and bridge. Customized REMI model of the Michigan economy was used to measure the industry sector impacts in terms of jobs. The general approach to determine the benefit was to generate: (1) mappings of program expenditures into the appropriate policy levers for the REMI model; (2) estimates of annual travel-time savings for households and businesses in terms of vehicle-hours of travel; and (3) the economic benefits accruing to the Michigan economy and its major industry sectors from these program expenditures and travel-time savings.	The recalibration of some of the industry results in the model to isolate the impacts on out-of-state tourism, a sector not explicitly broken out in the REMI model. They were able to take tourist-related industries, and for each of those industries, separate out the portion that was related to out-of-state tourism by using current information in the REMI model.
2008	Changes in the Maine Economy From Strategic Investments in the Transportation System	Maine DOT	Maine DOT & University of Southern Maine	The investments in the study were part of the Department of Transportation's Long-Range Plan. This study estimated the changes in the Maine economy that could result from a series of investments in the highway, transit, and freight (port and rail) elements of the Maine transportation system. TREDIS, which is specifically designed to examine the economic impacts of transportation, was used to conduct the analysis. The economic changes from transportation changes were then input to a large-scale econometric model of the Maine economy developed for the University of Southern Maine by REMI. The REMI model produced estimates of changes in employment and gross state product.	The analysis of economic impacts is limited by available data and the long time horizon used in the study. In addition, economic impacts represented in the study are only a part of the economic assessment needed to fully evaluate investment options.

TABLE 3.1  
(Continued)

Year	Name of Project	Source of Project	Prepared by	Summary of Conclusions	Application of the Work
2009	I-29 Corridor Study: Economic Impact Analysis	South Dakota DOT	The University of South Dakota	The study was to determine the local and state economic impact of a new interchange and an overpass. REMI TranSight was used. The input factors for the TranSight model were developed by comparing travel demand data from a base scenario without the overpass to the alternative scenario that includes the overpass. Both the 2015 and 2033 economic impact calculations are done comparing the base case to the scenario with the overpass. The results of this study show that the interchange provides significantly more positive and longer lasting economic impact than the overpass.	The travel data tables showed in TranSight display the number of vehicle-miles and vehicle-hours traveled within each region. They often provide no indication of the percentage of trips that originate in one region and terminate in another.

Data source: (3,33–41).

Moreover, these models tend to be very expensive and require substantial economic expertise on the part of the analyst in order to identify the appropriate inputs and interpret the results. Acquisition of data inputs can also be very time-consuming (4,44,48,49).

**3.4.2.1 REMI Policy Insight.** As the most widely applied example of a dynamic economic model, REMI has been extensively peer-reviewed in the professional literature and field-tested for over thirty years in not only the transportation area, but also in environment, energy, and taxation forecasting contexts. The methodology was first initiated in the mid-1970s by G. I. Treyz, A. F. Friedlander, and B. H. Stevens (Economics Department, University of Massachusetts) (50,51). A core version of the model was then developed for the National Academy of Sciences. REMI was established as a firm in 1980 and, since then, has been developing models that answer “what if” questions about the effect of policy initiatives on the economy of local regions.

The model structure consists of five major blocks: (1) Output, (2) Labor and Capital Demand, (3) Population and Labor Supply, (4) Wages, Prices, and Costs, and (5) Market Shares. REMI can forecast how alternative project or policy variables would change economic and demographic patterns, including business output and employment, wages, prices, business productivity, cost of living, and interregional migration of businesses and population (43). It produces forecasts for a base case and project alternative scenarios for each year up to a specified horizon year and is customizable by geographical area and by industry breakdown. The model has been generalized for all counties and states in the United States, or any combination of counties and states (10).

### 3.4.3 Dynamic Economic Models Specializing in Transportation Analysis

In recent years, dynamic economic models specializing in transportation analysis have been developed for the increasing needs of state DOTs and MPOs to analyze the benefit/cost impacts of transportation investment and the macroeconomic impacts of alternative long-range plans. These models generally incorporate dynamic economic models with transportation planning and travel demand models. Unlike general dynamic economic models, which require direct user impacts provided as inputs, these models will calculate user impacts of transportation projects as part of their processes. The applications of dynamic economic models specialized in transportation analysis include REMI TranSight from Regional Economic Models, Inc., and the Transportation Economic Development Impact System (TREDIS) by the Economic Development Research Group, Inc.

**3.4.3.1 REMI TranSight.** TranSight is a REMI model developed specifically to analyze transportation projects. It can test alternative transportation changes and quantify the short and long-term impact on jobs, income, population, and other economic variables, to describe how transportation improvements affect the competitive advantage of cities and regions. TranSight integrates REMI models with travel demand models, and is constructed with extensive data on emissions, safety valuation factors, and other data (52). TranSight utilizes economic geography by estimating how transportation projects can change the “effective distance” between regions on the basis of a composite average ground travel time or cost between county centers (53). Based on changes to the transportation network input

specified by the user, TranSight calculates changes in vehicle miles traveled (VMT), vehicle hours traveled (VHT), emissions, safety, and fuel demand. Effects on businesses are then calculated, based on transportation cost and access to commodities.

**3.4.3.2 TREDIS.** Like REMI's TranSight, TREDIS is a dynamic economic model that specifically focuses on transportation projects. It consists of travel cost, market access, economic adjustment, and benefit-cost modules. TREDIS takes a more finely-defined approach, using Geographic Information Systems (GIS) to evaluate how alternative projects may affect intermodal connectivity and travel times to airports, marine ports, intermodal rail terminals, highway networks and delivery access for different modes and trip purposes (54). TREDIS was developed by Economic Development Research Group, Inc. (EDRG), and built upon an earlier product called Local Economic Assessment Package (LEAP). LEAP was a development of the Highway Economic Analysis Tool (HEAT), which built upon the MCIBAS from Indiana (55). TREDIS can calculate direct and secondary impacts. The direct impacts are associated with the travel-related cost changes in the project itself. Those outputs can then be used as inputs for a regional economic model in order to project any induced economic benefits. These models include Regional Dynamics Model (REDYN), IMPLAN and the REMI PI model. Each model has its benefits, and the REDYN model is often chosen as the primary component by TREDIS (56). The final outputs of TREDIS include employment by industry, personal income, gross regional product, business output, national and state benefits, and export activity. The analysis of TREDIS can cover all transportation modes: road, rail, aviation and marine (52). In contrast to the models mentioned above, TREDIS is a web-based tool. Users can work with any internet-enabled computer or mobile device and collaborate with colleagues at multiple sites in real time. TREDIS is also scalable and multi-regional by providing self-defined local, regional, or statewide impacts. In addition, intermediate calculations are shown in TREDIS, allowing users to audit and validate simulation results.

## 3.5 Model Evaluation and Comparison

### 3.5.1 Economic Impact Model Evaluation

After reviewing the economic impact analysis software introduced above, a summary is presented in Table 3.2.

### 3.5.2 Economic Impact Model Comparison

#### 1. Coverage (Geographic resolution, and travel mode)

- a. TREDIS® has a more refined township data analysis level than other three packages, which are county-level at most. A microscopic study

like intersection impact analysis can therefore be conducted using TREDIS®. Generally, county-level analysis could meet most needs associated with state government projects by either aggregation to statewide analysis or disaggregating to TAZ level. The current version of REMI PI® that INDOT uses produces results at the state level. Some results for smaller geographic areas can be achieved through disaggregation by regression.

- b. TREDIS® encompasses a broad range of travel modes—road, rail, aviation and marine—on both passenger and freight transportation. TREDIS is the only software that can conduct intermodal analysis, which could be of great interest to state government and planning agencies, and especially useful for statewide transportation project analysis.

#### 2. Analysis efficiency (Impacts coverage, and client list)

- a. IMPLAN® can only estimate all the direct, indirect and induced impacts in a fixed year. REMI TranSight® and TREDIS® are able to estimate full economic development impacts over multiple years. Both REMI TranSight® and TREDIS are embedded with a travel cost model to estimate the direct user impacts and with a market access model to analyze business productivity and attraction effects, which are the intermediate inputs to the core forecasting model. However, for REMI PI®, only by combining with other similar models to construct a hybrid impact analysis system can it be made comparable to the two other models. It seems TREDIS® is more flexible, because the estimated effects depend on what kind of core forecasting model (REDYN, REMI PI) it is incorporated with, while REMI TranSight® can only rely on REMI PI model as its core component. Because MCIBAS, which is currently used by INDOT, is a good hybrid system comparable to REMI TranSight® and TREDIS®, the internal logic model for those three models or system are shown as Figure 3.1.
- b. Actually, all of these models are peer-recognized and widely used in transportation practice in the U.S. A large number of users from state and local government agencies, educational institutions and consulting firms have the experience using these models in economic impact evaluation. REMI software may still own the largest market share, because it is a regional economic impact package covering environment, energy, taxation and not just the transportation area. On the other hand, based upon its distinct intermodal interactions in transportation, TREDIS has been expanding its client list in recent years.

#### 3. Cost (Price, and human resource cost)

- a. The price of the license and maintenance fee to REMI series and TREDIS® are high among the impact analysis packages. Replacing an existing package would involve a large expenditure that

TABLE 3.2  
A Summary of Selected Economic Impact Analysis Models

Model type	I/O Model	Dynamic Economic Model	Dynamic Economic Model Specialized in Transportation	
Model name	IMPLAN ®	REMI Policy Insight ®	REMI TranSight ®	TREDIS ®
Latest version	3.0	9.5	3.1	3.6.4
Producer	Minnesota IMPLAN Group, Inc. (MIG)	Regional Economic Models, Inc. (REMI)	Regional Economic Models, Inc. (REMI)	Economic Research Development Group, Inc. (ERDG)
Selected state DOT users	MD, VA, WI	DC, IA, IL, IN, LA, MI, MS, ND, NM, NV, WI, ME	LA, MI, MN, NM, PA, SC, VA, WI, MO	KS, KY, ME, MA, MI, MN, MO, NC, NY, OR, VA, VT, WI
Portability	PC-based	PC-based	PC-based	Web-based
License and maintenance cost	(Counties + state) Packages for \$475~\$2,200 <sup>1</sup>	\$53,000 for initial + \$10,000/y for maintenance <sup>2</sup>	\$120,657~\$315,210 for initial (2~4 minimum salary, staff members included) + \$88,657~\$272,010/year for maintenance <sup>3,4</sup>	\$111,457~\$312,010 for initial (2~4 minimum salary, staff members included) + \$101,457~\$302,010/year for maintenance <sup>3,4</sup>
Most refined geographic scale	County	County (INDOT/REMI is State-level)	County	City or town
Scalability/compatible with other regional economic models			REMI PI (embedded)	REDYN (embedded), IMPLAN and REMI PI
Sectors aggregation scheme	User define as desire	53	53	
GIS capabilities		√	√	√
Visualized maps/plots output		√	√	√
Spatial factors incorporation		√	√	√
Long-term economic impacts estimation		√	√	√
Full economic development impacts estimation	√	√	√	√
Benefit/cost analysis				√
Passenger/freight interactions				√
Intermodal interactions				√
Embedded travel demand model			√	√
Multi-modal analysis			√	√
Traffic impacts output				√
Customized database		√	√	√
Model rental service		√	√	√
Prerequisite economic expertise or staff training for DOT		√	√	√
Technical support and training	√	√	√	√

Data source: <sup>1</sup>(57); <sup>2</sup>(58); <sup>3</sup>(59); <sup>4</sup>(57); (60).

would have to be justified by the advantages of doing so. REMI PI+® currently held by INDOT is relatively economical because of its low (i.e., state-level) geographic resolution.

- b. Besides the package license and maintenance cost, the cost of technical staff with expertise needed for proper operation may be required on account of the complex input entry and output translation. A Brigham Young University study used Full-Time Equivalents (FTE) to measure the personnel costs of economic impact models. REMI usually takes 1–3 FTE versus 0.5–1 FTE for IMPLAN (38). Kentucky Transportation Center found that TREDIS assumes that users would be planners or engineers and not full-time

economists. For data entry, only about 1 to 2 hours is needed (39). It seems that TREDIS® is easier than other alternatives for a State DOT to use.

Overall, considering that INDOT already has REMI Policy Insight® for impact analysis, any potential alternative should not only show obvious advantages in plausibility of results over REMI PI, but also be within the INDOT budget for operation and maintenance. However, the analyses above confirm that acquiring a new economic impact analysis package, either as a substitute for the current REMI or as a supplement to REMI, is not justified.

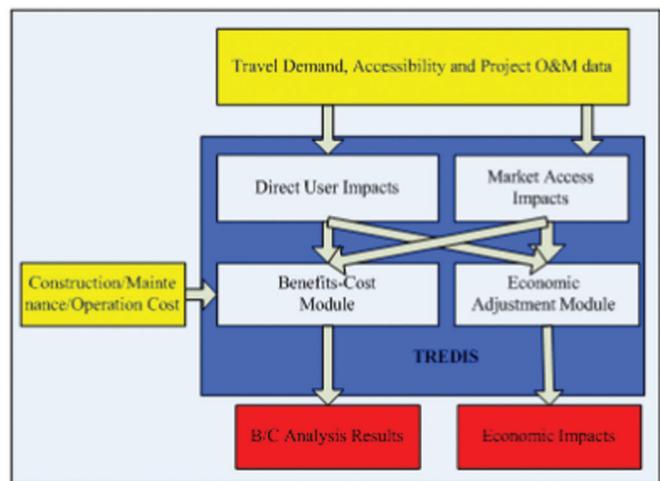
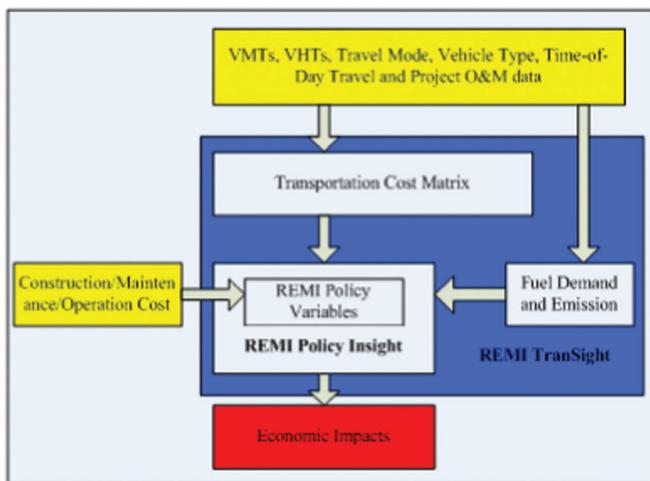
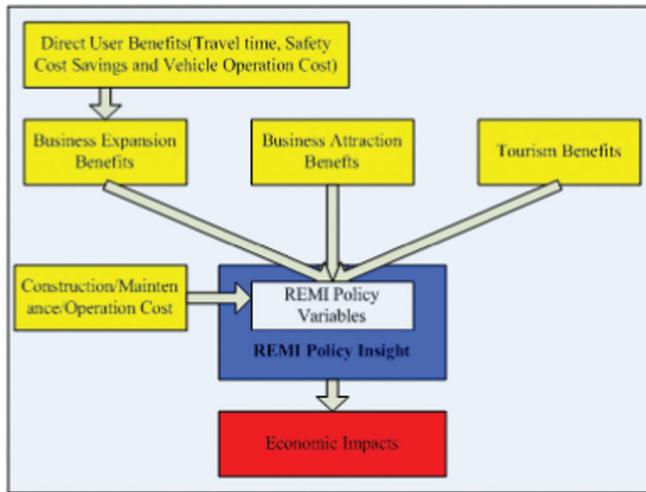


Figure 3.1 Internal logic model structure comparison for MCIBAS<sup>1</sup>, REMI TranSight<sup>®2</sup> and TREDIS<sup>®3</sup>. (Source: <sup>1</sup>(3); <sup>2</sup>(39); <sup>3</sup>(54).)

### 3.6 Case Study Using REMI

#### 3.6.1 Introduction

This case study, following INDOT’s MCIBAS process, is conducted to illustrate how to set up REMI policy variables and use them to estimate the statewide economic impacts of an assumed corridor improvement project in Indiana for the short term, as well as for the long term. It also presents the differences between no-invest and invest scenarios in terms of economic impact measures like total employment, total non-farm employment and Gross Domestic Product, from a REMI simulation. This case emphasizes the process of setting up and handling REMI, rather than an analysis of the forecast results.

The short-term effects include construction jobs and the secondary impacts of construction. They do not contribute to sustainable economic growth. Generally, the short-term effects of construction spending are estimated with the use of REMI. In accordance with the Indiana Long-Range Transportation Plan, the long-term forecast

period in the study is defined as 20 years, to forecast the statewide economic impacts of proposed improvements. In the case study, the forecasted improvement cost, user benefits, business expansion benefits, business attraction benefit tourism benefits and agency cost are projected from the tables in the 1995 US31 economic impact assessment report.

#### 3.6.2 REMI Input Analysis

According to the MCIBAS Components, these input data can be divided into five groups for the REMI analysis: (1) business expansion benefits; (2) business attraction benefits; (3) tourism benefits; (4) agency cost (operation cost and maintenance cost); and (5) social and environmental cost.

**3.6.2.1 Business Expansion Benefits.** The business expansion benefits can be estimated by the Business Expansion Module in MCIBAS. The estimated business automobile and truck-related travel efficiency benefits are allocated to various types of existing

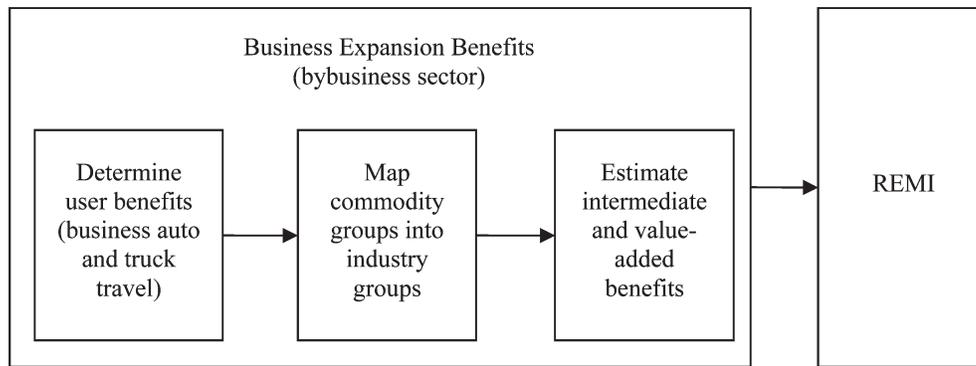


Figure 3.2 Business expansion benefits into REMI.

TABLE 3.3 Highway User Costs (Millions of \$2011)

	Vehicle Operating Cost:			
	Travel Time Cost: 2011–2030	2011–2030	Safety Cost: 2011–2030	User Cost: 2011–2030
Non-work auto	\$2,301	\$-272	\$1,190	\$3,218
Work auto	926	-86	445	1,284
Truck	287	-23	102	366
<b>Total</b>	<b>\$3,513</b>	<b>\$-381</b>	<b>\$1,736</b>	<b>\$4,869</b>

TABLE 3.4 Part of Intermediate Inputs and Value-Added Benefits by Sectors: 2011–2030 (Million \$2011)

	Manufacturing	Food Manufacturing	Real Estate	Retail Trade
Intermediate inputs cost	\$-21.8	\$-10.9	\$-16.35	\$-5.45
Value-added benefits	\$880	\$176	\$264	\$88

businesses located in the state. These business expansion impacts by industrial sectors (there are 53 industries defined in the REMI model) are used as direct impacts for entry into REMI. The steps for driving intermediate and value-added benefits from user benefits are shown in Figure 3.2.

- A. **User Benefit Estimation.** The total user benefits are estimated by a Network Post-Processor for User Benefits (NET\_BC) in MCIBAS. User benefits refer to the travel time, cost, and safety improvements that are realized by travelers. Personal auto trips of auto user benefits associated with commuting to and from work do not affect business costs. Only user benefits related to business auto trips are considered in the economic analysis. Effects on non-travelers are not counted in the analysis of user benefits (as Table 3.3 shows).
- B. **Intermediate and Value-Added Benefits Estimation.** These direct business cost savings are allocated among industries based on the relative sensitivity of each industry to highway-related costs, weighted by each industry’s share of the state’s economic activity. Industry output is a combination of intermediate inputs (i.e., purchase of commodities or services) and value-added (labor, taxes, and profits). The benefits were totaled by industry and distributed between intermediate inputs and value added based on the national input/output technological matrix. Table 3.4 shows the

partial result of Business Expansion Benefits Estimation, which is input to REMI.

**3.6.2.2 Business Attraction Benefits and Tourism Benefits.** The business attraction benefits and tourism benefits are supposed to be estimated by the Business Attraction Module and Tourism Impact Module in Indiana MCIBAS separately. As Table 3.5 shows, the analysis identified industries that are dependent on highway access, and have the potential for attraction to the study area based on the highway benefits. In general, these businesses depend on high volumes of truck shipments and timely delivery of supplies.

Additional visitors will contribute to the regional economy by spending money in various sectors. See Table 3.6.

**3.6.2.3 Agency Cost.** Agency costs refer to changes in improvement and maintenance costs as a result of changes in funding levels. Improvement and maintenance costs are incurred by the INDOT to improve and maintain the highway system. The project was constructed in 2010 and will be maintained on the annualized basis through 2011–2030, as shown in Table 3.7.

TABLE 3.5  
Highway Business Attraction Employment by Sectors

Industrial Sectors	Motor Vehicles and Parts Manufacturing	Fabricated Metal Products	Rubber and Plastics	Electrical Equipment	Retail Trade	All New Jobs
Employment/ year	85	56	28	18	13	200

TABLE 3.6  
Highway Tourism Benefits by Sectors (Millions of \$2011)

Industrial Sectors	Accommodation	Restaurants	Personal Services	Retail Trade	All Tourism Benefits
Million/year	\$3.0	\$2.4	\$0.8	\$1.8	\$8.0

TABLE 3.7  
Changes in Operation Costs and Maintenance Costs for REMI Input (Millions of \$2011)

(Short-Term Input) Operation Cost 2010	(Long-Term Input) Maintenance Cost 2011–2030
\$1,100	\$0.37/year

**3.6.2.4 Social and Environmental Benefits.** These benefits are seldom fully represented in benefit-cost analysis, because of the lack of public agreement on the valuation of environmental and social factors. The variables refer to the changes in noise and emission costs estimated by the ISTDM. Social and environmental benefits can be input to the “Non-Pecuniary Amenities Variable (Amount)” on an annualized basis in REMI.

### 3.6.3 REMI Simulation Runs and Results

**3.6.3.1 Policy Variable Selection.** REMI’s strength is as a policy analysis model. The specific REMI policy variables category selection in terms of different economic benefits and costs of the case is shown in Figure 3.3.

**3.6.3.2 REMI Input Setting.** The benefit/cost tables by various industrial sectors can be input through a spreadsheet for the REMI simulation, as shown in Figure 3.4.

**3.6.3.3 REMI Simulation Results.** The employment and GDP forecasting results by REMI can be found in Figure 3.5 and Figure 3.6. The long-term difference in employment is decreasing, with a higher rate of decrease in the first few years after the construction year due to the decreasing short-term impacts. For the long-term GDP, it does not change much after the big jump shortly after the construction year.

## 3.7 Conclusion

This chapter looked at several economic impact analysis methods. REMI as a dynamic economic model is supposed to have as input to its policy variables other business expansion/attraction benefits, tourism benefits, and the agency costs before undertaking a regional simulation to determine economic impacts of a transportation project. The analysis in this chapter included several widely-used economic impact analysis

Period	Benefits and Costs		Policy Variable Categories	Detail Selection
Long-Term	Business Expansion Benefits	Intermediate Inputs Cost	Production Cost (Amount)	All Industrial Sectors
		Value-Added Benefits	Industrial Sales/Production (Amount)	All Industrial Sectors
	Business Attraction Benefits		Industry Employment (Industry Sales/Exogenous Production) (Number)	Related Industrial Sectors
	Tourism Benefits		Category Industry Sales/Exogenous Production (Amount)	Related Industrial Sectors
Short-Term	Agency Cost	Maintenance Cost	Government Spending (Amount)	—
		Capital Improvement (Construction) Cost	Industry Sales/Exogenous Production (Amount)	Construction Sector

Figure 3.3 REMI policy variables setting.

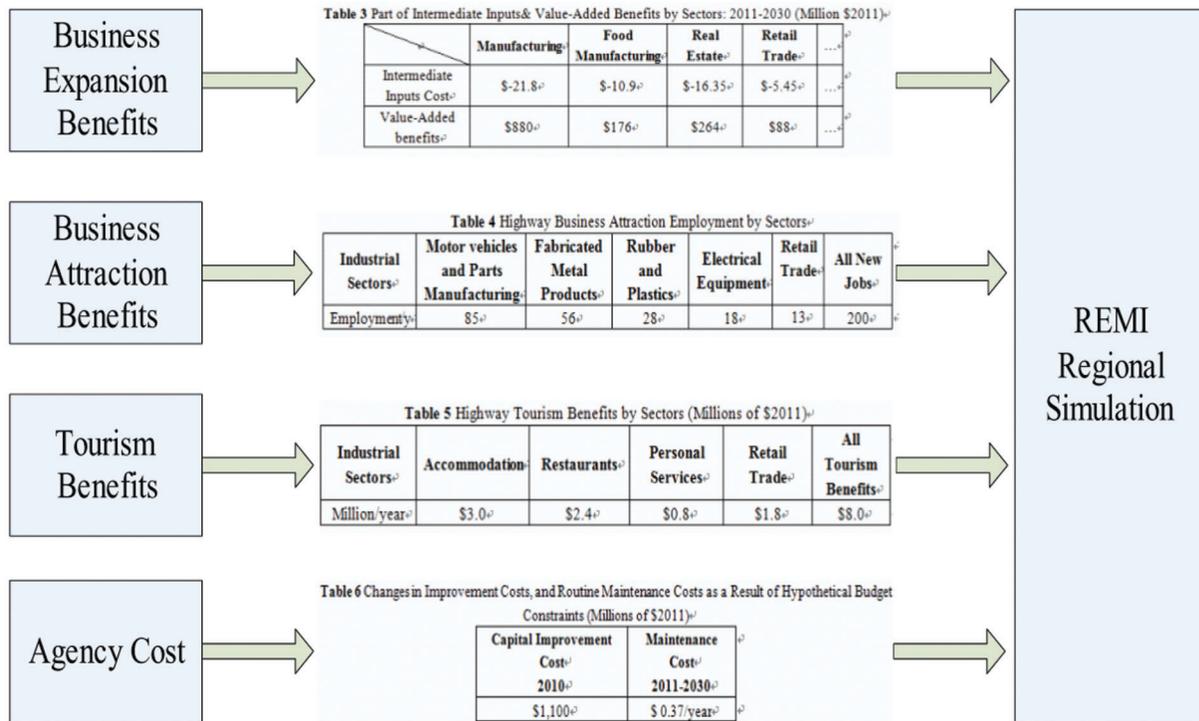


Figure 3.4 Inputs to REMI simulation.

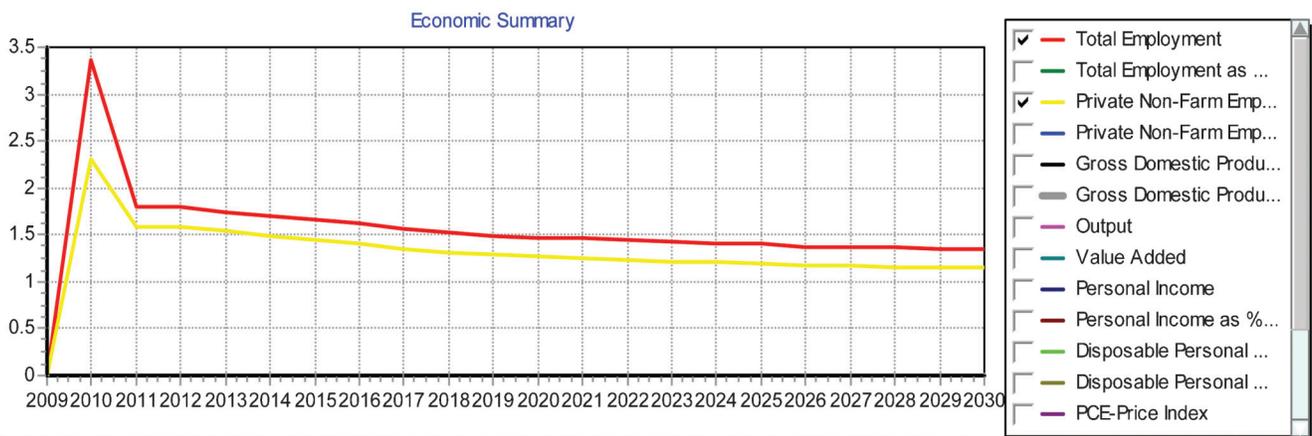


Figure 3.5 Differences of forecasted employment between invest and non-invest scenarios (thousands of jobs). (Data source: (27).)

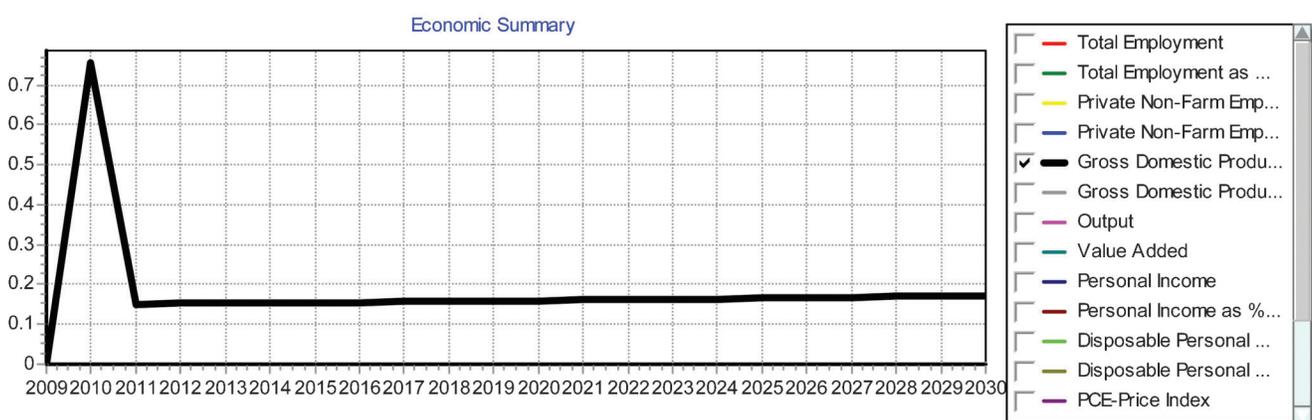


Figure 3.6 Differences of forecasted GDP between invest and non-invest scenarios (billions \$2011). (Data source: (27).)

models—IMPLAN, REMI PI+, REMI TranSight and TREDIS—for possible application to INDOT projects. It was found that dynamic economic models like REMI TranSight and TREDIS that specialize in transportation often have higher geographic resolution and wider coverage in impact analysis, but also have higher license and maintenance costs. There may be advantages from having an in-state group providing its model and expertise to INDOT, but three factors must be considered—continuity, user customization, and cost:

1. Changing models will lose the continuity of the working relationship between INDOT personnel and REMI. The characteristics of the data produced by the new firm may not match the data that had been produced by REMI, if that is important. The discontinuity may be minimal if the new firm uses similar standard modeling methods and adopts the same data definitions and sources as REMI.
2. IU’s Center for Econometric Model Research (CEMR) is capable of conducting economic impact analyses. However, REMI allows a user to choose and adjust policy variables for economic impact analysis. CEMR would be useful for statewide forecast comparisons.
3. If INDOT elects to use CEMR to supplement REMI, that would increase the costs to INDOT. However, it is likely that CEMR’s compensation would be less than REMI’s. In either case, INDOT would have to verify that confidence in a CEMR economic impacts analysis of transportation projects is justified.

## 4. TRANSPORTATION INVESTMENT AND BUSINESS LOCATION

### 4.1 Transportation Investment and Economic Growth

The goal of the highway system is to provide individuals with mobility and allow for the movement of goods in a safe and reliable manner (61). Businesses are able to move raw materials and processed goods through the supply chain using the transportation network. Consumers are able to use the highway infrastructure to travel to retail locations to complete business transactions.

Transportation is one factor in the production function for economic growth. Highways can generate economic development by creating a route between regions, allowing for new kinds of business undertakings that would not be

possible in an isolated environment (62). Economic development is a relative concept. A region must grow at a faster rate than other areas for its relative position to improve (63).

Investment is required to maintain the quality of the highway network and to expand it. The federal Transportation Equity Act for the Twenty-First century required that transportation projects are evaluated with respect to economic growth. Statistical models (production and cost functions, or regression models) have been generated to identify the relationship between transportation investment and changes in business output, productivity, employment and income growth (64–66). Time-series studies have analyzed how the current levels of transportation infrastructure have affected nationwide economic productivity and growth (67–70). (See Table 4.1.)

#### 4.1.1 Transportation Economic Impacts

New road construction can be an economic development tool by creating a common meeting place between buyers and suppliers. It can also connect economically isolated areas to larger markets. The association between transportation investment and economic growth, however, is not well-defined. Econometric models fail to demonstrate clear connections (61). The cumulative effects on economic development such as jobs, income, and business growth have been primarily misestimated by impact software. In response, some transportation planners rely on expert panels to refine quantitative model results before making final project recommendations (6).

Nadiri and Mamuneas (71) indicate that there are three broad categories of economic benefits from highway investment. First, employment positions are created by the construction of the highways. Second, road users benefit through time savings, safety enhancements, and vehicle operating costs reductions. Highway investments benefit consumers in that they reduce the cost of moving people or goods (72). The benefits to consumers also include additional leisure time, location and size of housing decisions, purchase of vehicle decisions, and transportation-related services affected by highway investment (61). Third, the investment promotes efficiency through the adoption

TABLE 4.1  
Studies Examining the Relationship between Transportation Investment and Economic Growth

Study	Conclusion
Evers et. al., 1987 (64)	A high-speed train between Amsterdam and Hamburg will lead to a reduction of travel time increasing the spatial interaction and economic development of each region
Duffy-Deno and Eberts, 1991 (65)	The amount of public capital stock has a positive impact on per capita income
Aschauer, 1990 (67)	Increased highway capacity is linked to an increase in the marginal product of capital. The higher marginal product of capital helps facilitate additional investment in physical capital and leads to an increase in per capita income and productivity
Munnell, 1990 (68)	States that investment more in infrastructure are likely to have more output, private investment, and employment growth
Boarnet, 1995 (69)	An extra unit of highway infrastructure is not associated with extra national or state productivity
Nadiri and Mamuneas, 1998 (70)	Total highway capital aids significantly to national economic growth

of new transportation technologies, increased route access and reduced costs.

Nadiri and Mamuneas (70) also indicate that the highway network has three economic benefits for manufacturing firms: (1) leads to production savings, (2) aids productivity growth and (3) has a positive net social rate of return. Highways are an unpaid input in the production function, reducing the cost of firms' production (70).

Evaluation procedures to analyze the economic effects of planned transportation projects have changed since the middle of the 1990's. Prior studies used to predominately examine road users' time and cost savings. The studies today have grown to include economic impacts related to job growth from connectivity between cities and the site selection choices of new firms (46). Analyses have also been used to estimate the impacts on economic productivity, job creation, income generation, improved public health and safety, environmental quality, residential and business location and subsequent job opportunities and income inequality (61).

Transportation investment projects are also evaluated on a variety of other economic-development factors, including wage increases, private investment, local tax base growth, the ratio of wages and property tax revenues generated per dollar of public investment, and the ratio of jobs created per dollar of public investment (47,62).

Huddleston and Pangotra (73) state that transportation appears to be a necessary, but not sufficient, condition for generating economic development. The specific nature of the various highway-induced economic-development impacts can vary significantly from project to project, depending on highway location, site-specific economic conditions, travel markets served, and the highway project's impacts on accessibility and system-wide connectivity (74).

Studies conducted in the 1980s have mixed results as to whether there is a significant relationship between highway investment and economic growth. Highway improvements alone may not impact development. Socioeconomic variables and other local factors are attributed to economic growth (33). Fox and Smith (63) note that infrastructure cannot be expected to enhance community development in all geographic areas.

Recent macroeconomic literature documents a strong correlation between infrastructure and productivity in the United States and other Western Economies (75). Munnell (76) contends that infrastructure investment has a positive impact on economic growth. This measure of public capital has a positive impact on the following state-level economic factors: output, investment and employment growth. The elasticity of public capital with respect to output was 0.15, approximately half the estimate at the national level.

The impacts associated with highway improvements are classified as direct effects, indirect effects, and induced effects. Direct effects are those benefits attributed to the project, such as travel time cost savings and safety benefits associated with the improvement of the traffic conditions on transportation system.

Indirect effects are spillover impacts that refer to the economic benefits derived by suppliers for its services with the primary industry. Examples of these impacts include the number of professionals hired from concrete mixing companies and guard rail manufacturers. Induced effects result from the spending of the new workers in the primary and secondary industries (33).

Projects that focus on adding lanes, interchanges and new highways have been shown to have a greater potential for indirect impacts through job creations, income and business growth than projects to improve current roads (6,23). A new transportation infrastructure project could have a lesser impact on areas with a mature transportation network than in a less developed network (6,70).

Highway investment is generally not warranted in areas where volume-to-capacity levels (congestion) are low. Interstate development and expansion is generally considered in areas where projected traffic volumes are very high (72). Road congestion does have an adverse effect on economic development (46). An ongoing problem in urban areas is that traffic volumes are increasing relative to capacity improvements. This has caused more delays and negative externalities such as increased carbon dioxide emissions, less leisure time, and loss of business activity for firms that rely on the road network. Delays can impact the frequency and reliability of product shipments. Fuel cost and motor vehicle depreciation increase as vehicles are stalled. Individuals spending more time in traffic have less leisure time in which to consume private goods and services (46).

#### *4.1.2 Highway Benefits and Rate of Returns*

There are social and economic benefits derived from highway investment. Some of the primary user benefits include the reduced cost of moving people or goods (77). This includes additional leisure time and reduced vehicle operating costs (6). Transportation infrastructure is also seen as a public social benefit in that it can help individuals lead a better quality of life with improved access to services. The economic benefits to states and nations are centered on jobs. This includes increased employment, wages and output (76). Maumuneas (78) concludes that highways provide benefits to the economy; investment should be continued until the net rate of return falls below the interest rate. Recent research has indicated that the return of return to highway investment has decreased following the peak that it once gave certain areas (61). The United States highway network is mature and has a lesser impact on business location decisions, because most cities are already connected to primary routes in the highway system (72).

#### *4.1.3 State Highway Funding and Impacts*

Weibrod and Gupta (62) reported on the results of a consulting firm's study examining how each of the 50 states evaluated self-funded road infrastructure plans during the 2001 and 2002 fiscal years. The study

identified four broad categories of state department of transportation involvement with highways in regards to economic development:

1. Funding Initiatives for Local Access Roads. These are programs that use state funding to connect intercity highways to nearby business districts or industrial parks.
2. Funding for Inter-City Connector Routes. These projects use state funding to connect isolated and economically depressed areas to the interstate highway system and agglomeration economies.
3. Policies Recognizing Development as a Determinant in Funding Choices. These states have limited funding with which to construct roads for the primary purpose of economic enhancement, but do consider the economic development impacts of highway projects.
4. States without Formal Programs Assessing Economic Development Impacts. Eleven of the 50 states do not have specific policies requiring the economic development of highway projects.

Weisbrod and Gupta (62) report that there are four economic development classifications of formal state road construction programs. Each considers some level of desired economic improvement:

1. State Road Programs with Defined Economic Development Specifications. These are state programs with designated funding for road projects needed to attract businesses to the area or to get them to expand existing state operations. The state department of transportation will assist funding the program, if a certain level of private investment is committed to creating new jobs and bringing money to the geographic area.
2. State Road Funding for Specific Local Areas. These are state programs with designated funding for road projects to assist business parks and other operations in need of economic development. There are no minimum economic development requirements for this classification.
3. State Road Funding in Partnership with State Economic Development Office. These are state programs geared towards providing funds to local road projects. Communities must apply for these state grants and the basis of the decision is the projected economic impacts versus the area's current economic development needs.
4. Planned Economic Development Highway Corridors. These are state programs that try to connect economically depressed areas to markets. The projects are typically awarded to small- and medium -size communities whose development efforts are behind those of other cities within the state.

## 4.2 Location Theory

Highways play an integral part in the economy (61). Jones and Woods (79) and Brown, Florax and McNamara (80) note that the National Interstate Highway System has opened industrial possibilities to the vast majority of rural America, especially in the south. Local governments often indicate that businesses are persuaded to locate to areas well served by high-capacity highways as it makes them more competitive and lowers their relative costs (72). MacCormack, Newman, and Rosenfeld (81) contend that a well-built transportation network can

help firms get direct access to suppliers and develop a competitive advantage.

Transportation facilities are an element in the cost function that firms face. A place of employment may locate at an interchange of two major highways, because of the proximity to road services, which decreases transportation costs. The lower transportation costs are seen as attractive to new businesses. An increase in business activity attracts other businesses that seek close proximity to suppliers or customers. Highway projects are generally awarded to areas that face high congestion instead of areas where the road is used infrequently. Investment can lead to an increase in traffic flow, which in turn can have positive economic impacts, such as job creation or income change (61).

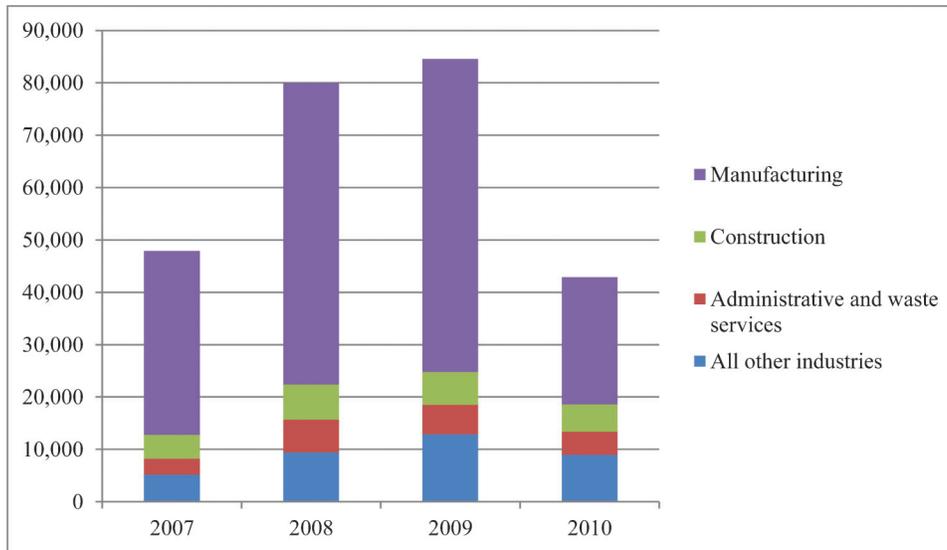
Weisbrod (46) mentions four ways that highway expenditures can impact economic development and act as a location factor: (1) new roads providing access between industries and individuals, (2) improved transport system reliability minimizing product damage, (3) increasing product markets allowing for lower marginal costs with production and distribution, and (4) improved efficiency with proximity to additional labor and supply-chain intermediaries.

### 4.2.1 Indiana Manufacturing Employment

The manufacturing segment employs the largest number of people in the Hoosier state and, as a percentage of total state employment, is one of the highest in the nation. The manufacturing segment is a critical component of the state's economy. In recent years, many manufacturing jobs have relocated to lower-cost countries or been displaced due to advances in technology (80,82-84). Evidence suggests this, as Indiana's manufacturing sector has decreased from 19% of total state employment in 2000 (697,610 manufacturing jobs) to 13% (453,196 manufacturing jobs) in 2009 (42). Meanwhile, gross state product in manufacturing has grown from 57 billion dollars in 2000 (adjusted for inflation) to 75 billion dollars in 2010 (42).

In 2008 and 2009, there were 680 and 730 mass layoff events (see Figure 4.1), respectively, with each layoff event resulting in at least 50 job separations. The manufacturing sector accounted for 436 of the occurrences in 2008 and 470 in 2009. Approximately 80,000 individuals claimed unemployment insurance in 2008 and 85,000 in 2009 due to the layoff events (see Figure 4.2). Nearly 60,000 jobs were lost in both of these years (21).

The mass layoff events occurred in both urban and rural areas. In the late 1990's and early part of the twenty-first century, many temporarily laid off workers in urban locations were re-hired as business conditions improved. The rural locations were more likely to cease operations. The presence of highway infrastructure put urban areas at an advantage, because it gave potential investors an incentive to locate there to have closer access to business services and agglomeration economies. Rural areas were more likely to have less to offer



**Figure 4.1** Mass layoff initial claims, Indiana, annual totals, 2007–2010.

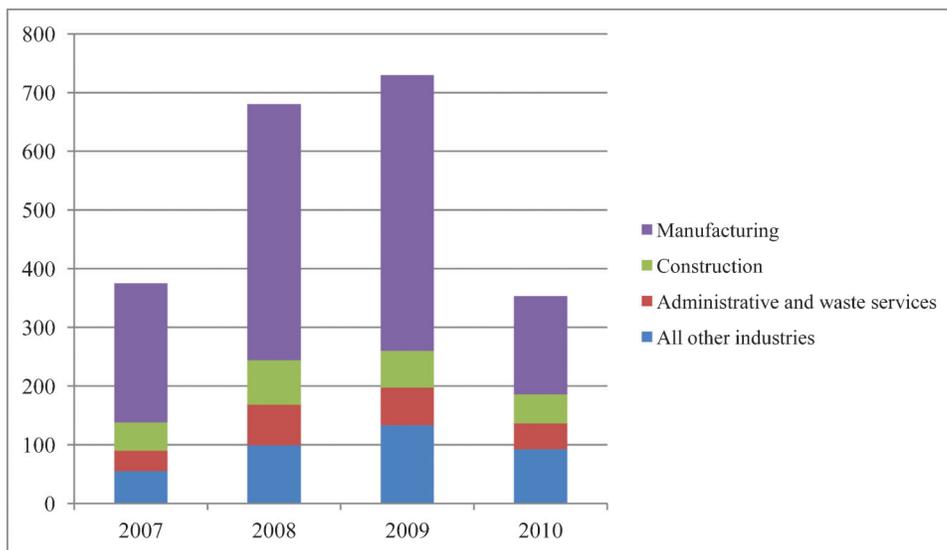
in terms of proximity to the interstate and business services. The presence of an interstate offers local firms close access to outlets throughout the country. However, it does not guarantee that firms will locate in a specific location.

#### 4.2.2 Business Location Surveys

Schmenner (85) conducted a three-prong study of business location decisions by Fortune 500 companies across the United States. His results conclude that transportation was a significant issue only in 2% of the cases when large scale businesses were choosing a site. Transportation was seen as not as important as labor climate, market access, quality of life, resources, labor rates, proximity to current facilities, environmental permits, and facility/land availability.

Dow Jones and Co. and Site Selection magazine conducted surveys with senior officials on business location decisions. The results found highway proximity to be one of the most important determinants of site choice for corporate headquarters, manufacturing facilities, and distribution centers (33).

Forkenbrock and Foster (72) conducted a large-scale survey across Iowa in 1992 and 1993, mailing questionnaires to managers of all manufacturing facilities in the state believed to employ 50 or more workers about policy issues affecting the Midwest economy. They sent a similar type questionnaire out in 1993 to major businesses and industry employment centers throughout Missouri. Of the Iowa recipients, 66% were involved in manufacturing, compared with 58% for Missouri. Missouri was more concentrated in the warehousing/distribution sector with 28% of the



**Figure 4.2** Mass layoff events involving 50 or more job separations, Indiana, 2007–2010.

recipients involved in this area, compared to 24% for Iowa. Only 4% to 5% of respondents 10 to 20 miles from an interstate highway and 9% to 11% over 20 miles from one felt they were “hurt significantly” by the distance from the interstate. A majority of those surveyed indicate that their locations had neither an advantage nor disadvantage on their competitors.

The respondents in this study were also asked to rank the following seven factors in regards to the competitive nature of the industry: labor quality, labor costs, proximity to markets, proximity to input materials, transportation services, utilities and tax rates. Seven of the 219 Iowa respondents listed transportation services as the most important factor. Overall, transportation services ranked as the fifth most important factor on the list. 44 of the 235 participants in Missouri ranked transportation services as the most important factor, placing it as the third most important factor. Forkenbrock and Foster (72) state that four-lane highway access is not necessarily an important determinant of location choice. Factors such as labor quality and labor costs may play a more vital role.

Investment Weekly (86) says that six keys to plant site selection in today’s environment are labor needs of the business, proximity to clients or vendors, transportation needs, local tax situation, property requirements, and quality of life.

#### 4.2.3 Manufacturing Location Decision

Manufacturing plant decision is a two-stage process (82,84,87–94). In the first stage, companies choose a region based on the firm’s overall goals, such as product markets, access to raw materials, or other objectives. In the second stage, firms choose a minimum cost site within the selected zone.

Manufacturing plant site selection committees generally do not look for an individual state in the first stage of the location model. Many states have the attributes that firms seek for making a first-stage, regional-level location decision, such as transportation infrastructure, resource endowments, and economic synergies (95). In the second stage, local features impacting site choice can be isolated from the regional setting, giving decision makers a clearer idea about which community attributes are important in attracting outside investment.

The dynamics of globalization and the international marketplace have unknown impacts for rural areas to recruit export-led industries (84). The migration of manufacturing from large urban areas to low-cost labor locations stimulated rural development in the early 1970s (84,96,97). The rural manufacturing sector expansion continued until the 1980s (84).

Rural areas have struggled to maintain export-led sectors over the last decade, as manufacturing has moved back to urban areas having access to skilled labor, business services, and product markets (84,96,98,99). The focus of manufacturing in urban areas increased because of the amplified importance of a skilled labor force, supply chain logistics, and scale economies (84,100,101).

The cost minimization framework of the early 2000s encouraged manufacturers to seek low-wage workers abroad (82–84). Recent manufacturing plant location research by Lambert, McNamara and Garrett (102) suggests that manufacturing site selection is becoming further impacted by proximity to raw materials, customer markets, business services, and manufacturing agglomeration. Highway investment is viewed as a positive component of site selection.

Manufacturing employment in the United States has been on a steady long-term decline since the 1960s. Real investment on total capital and manufacturing output has been increasing. During this 40 year-period manufacturing increased its capital intensity, especially with the integration of computer technology into labor (80,103). The patterns of wages and employment suggest technical changes resulting in increased demand for skilled labor.

Research by Dalenberg and Partridge (104) and Fernald (75) has suggested that manufacturing firms seem to benefit more from highways. They are able to create economies of scale with close proximity to highways, which helps ease the burden of production and operations. Firms seek a location that provides access to materials and decreases transportation costs associated with the procurement of heavy, perishable, watery or immovable resources (105,106). The quality of labor also affects manufacturing output (92).

Smith et al. (107), Woodward (94), and Rainey and McNamara (108) looked at the infrastructure effects at the county level, with all concluding that it was a positive explanatory variable on plant location decision. Bartik (87,95), Glickman and Woodward (109), and Coughlin et al. (110) found infrastructure to be a positive determinant on manufacturing location at the state level. Without an advanced transportation network, manufacturers would not be able to perform the most efficient operations (61).

#### 4.2.4 Location Theory and Econometric Studies

Statistical models (production and cost functions, or regression models) have also been generated to identify the causal relationship between transportation investment and changes in business output, productivity, employment and income growth (64–66). Several of the statistical models contain numerous variables making it challenging to interpret the economic impacts.

Lombard, Sinha, and Brown (66) conducted a study examining the relationship between highway investment and economic development in Indiana at the county-level using data between 1980 and 1988. Limited models that focused on highway measures explained 14% of the variability in the change of economic development between 1980 and 1988. The comprehensive models explained more of the variability in the changes of total employment and wages during the study period. Highway mileage was a positive growth determinant, while a dummy variable assigned to the percentage of poor roads was a negative influence on growth. The total expenditures on highway growth were not relevant

in terms of economic development in the state. The percentage of college graduates in a county was highly significant and positive, while property tax rates were a highly significant negative factor.

Gkritza et al. (6) conducted a study in Indiana to determine business attractiveness and economic development impacts over a 20 year period based on 117 lane addition and road improvement projects throughout the state. The economic impacts were modeled using simultaneous equation modeling to estimate the change in employment, real disposable income, output and gross regional output. The greatest economic benefits in terms of employment, wage, and business growth are from interstate highway improvements rather than projects on state and county highway systems. This may be due to industries in manufacturing and other sectors, which are highly reliant on the interstate system for product movement throughout the state of Indiana (6). Areas close to major airports have higher employment, real disposable income, output, and gross-regional product impacts.

The location of a project was found to have an influence on the magnitude of the economic development benefits. The marginal benefits of adding lanes in rural areas with an undeveloped highway network will be larger than adding new lanes to metropolitan areas with an established highway network (6,70). New-road construction projects were likely to be awarded to areas with limited proximity to employment, airports, universities compared to other types of projects. The study showed that interstate lane addition projects, building interstate interchanges, and constructing new roads for areas with limited connectivity are likely to have greater long-term economic benefits with respect to output, employment and wages. Projects that improved road quality or the addition of a median were likely to yield minimal development impacts. Interstate highway interchanges give firms a more direct access to customer markets (6,111). The results also show that the cost of the project was not the most important factor in terms of economic benefits. The type of highway (interstate, state, county) and proximity to airports and places of employment were in some cases the most important determinants of economic-development.

### 4.3 Summary of Manufacturing Location Decisions

The impact of agglomeration, labor, infrastructure, market, and fiscal characteristics had varying impacts on the desirability of firms to locate to a specific region. The majority of the studies concluded that the presence of the interstate highway access or length of the interstate highway access is a positive factor in regards to plant recruitment.

The relationship between transportation investment and economic growth is undefined. The connections are not well quantified and numerous econometric studies have failed to signify the relationships. Researchers indicate that transportation infrastructure appears to be a necessary, but not sufficient, condition for generating economic development. Highways alone likely cannot facilitate economic growth. The presence of agglomeration

economies and the clustering of business services appear to be a determinant for development.

The economic development aspects of roads can be analyzed in two forms: individual and societal. Road users benefit through time savings, safety enhancements, and vehicle operating costs reductions. The benefits to consumers also include additional leisure time, location and size of housing decisions, purchase of vehicle decisions, and transportation-related services affected by highway investment. The societal impacts include but are not limited to economic productivity, job creation, income generation and business location decision.

The location decision of manufacturing firms is a factor of five general subject areas: labor, markets, fiscal, agglomeration and infrastructure. Each component has a varying degree of significance on a firm's likelihood to locate in a specific area. The presence of an interstate highway in a county and the length of the interstate highway system in it are a positive determinant of a firm's location decision. The location decision of firms has been impacted in recent years by changing production technologies.

## 5. USING AN EXPERT PANEL TO REFINE ECONOMIC FORECASTS

### 5.1 Introduction

Based on the statewide forecasts from REMI PI+ version 1.2.4 (Build 2199) shown in Figures 5.1 and 5.2, the long-term economy seems more reasonable than the forecasts of a previous REMI version (shown in Figure 2.4). The structural changes in the U.S. economy during the first decade of the twenty-first century are being incorporated in REMI's historical database. The dips and rebounds that occurred toward the end of that decade are also included. It is impossible to anticipate events that could have a significant impact over the next 20 to 30 years. All that can be expected from an economic forecasting model is a reasonable trend over the long term.

### 5.2 An Expert Panel in Michigan

In Michigan, a group called the Transportation Technical Committee (TTC) is involved in the fine tuning of REMI forecasts. The TTC meets with economists from the University of Michigan about every 3 to 4 years to review the latest statewide economic forecasts and provide input that may improve the forecasts before they are used in statewide and local travel demand models. At the most recent meeting of the Michigan TTC (Tuesday, August 23, 2011), there were 32 attendees. They included two University of Michigan economists, several Michigan DOT representatives, the State Demographer, representatives from most MPOs in Michigan, and a representative from DT Energy.

The first hour of the Michigan TTC meeting was devoted to presentations by University of Michigan economists George Fulton and David Grimes. It was clear from the start that most of the attendees have had

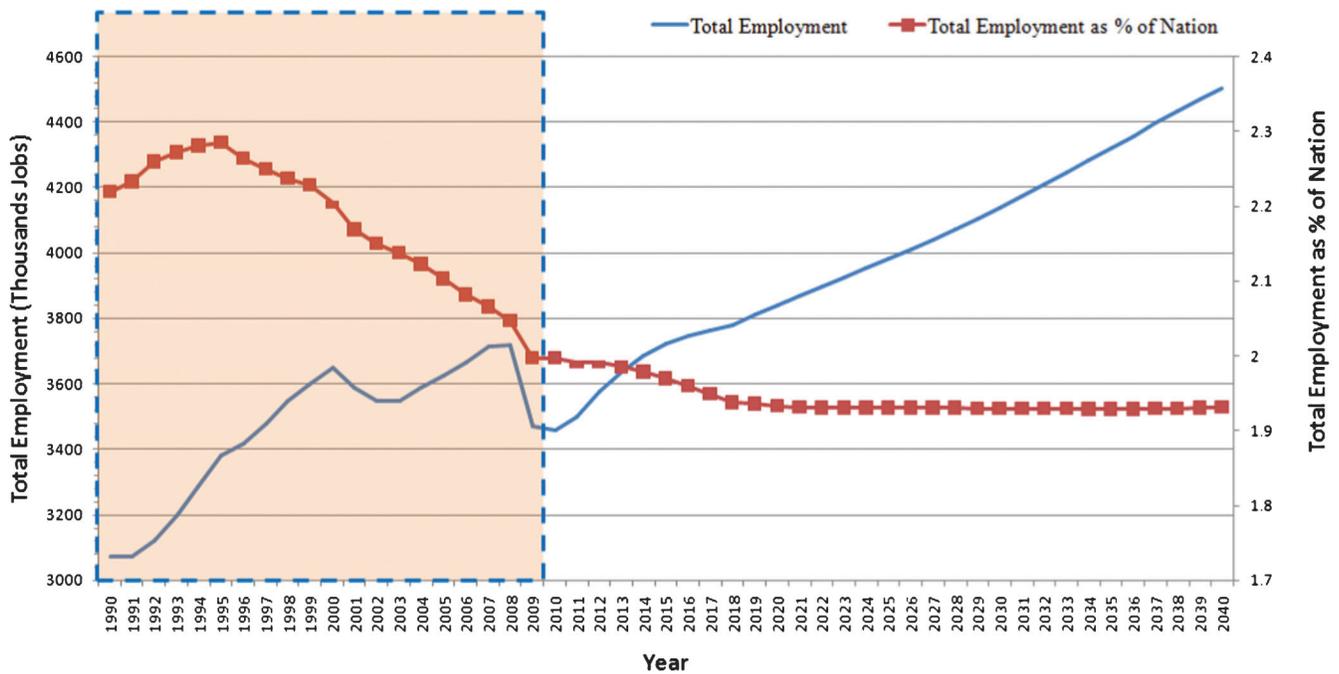


Figure 5.1 REMI baseline forecasts of total employment for Indiana state. (Data source: (27).)

a long and cordial relationship with the two Michigan faculty members. Dr. Fulton began by pointing out (especially to the guests) that a detailed version of the preliminary REMI forecasts had been sent to the MPOs several weeks before this meeting by Garth Banninga of MDOT Planning’s Statewide Model Unit. The preliminary forecasts contained information such as real GDP, population, natural changes in population, in- and out-migration, age cohorts, and employment by 70 industrial divisions. This is the fifth cycle of forecasts produced for Michigan DOT and the state’s MPOs, beginning in the 1990s.

The purpose of this meeting was to explain the preliminary results, begin a critique of the forecasts, and solicit input from the MPOs that could be used to tweak the REMI model. The focus at this meeting was at the state level. The final economic forecasts are expected in February 2012. They will also include personal income, households, and productivity (output per worker). Dr. Fulton covered (1) the relationship

$$\Delta \text{population} = \text{natural } \Delta \text{pop} + \text{net migration}$$

and (2) how the labor force participation rate interacts with working age population to affect employment totals. He explained that long-term forecasts attempt to capture economic trends, but can’t predict business cycles or major one-time events. Special cases, such as university areas, may have to be treated with specific attention.

Dr. Grimes covered the *Forecast of Real GDP* for Michigan. He talked about how a business tax decrease, personal tax increases, and new plants such as the battery plant in Pontiac will affect the forecasts. He reminded the TTC that REMI uses Bureau of

Economic Analysis data, which includes self-employed individuals and proprietors. More importantly, the recent REMI model was based on 2008 data, which started the forecasts in a direction more pessimistic than would have occurred if the 2009 data (not then available) had been included. The UMich economists are working to incorporate the newer data.

Historical and future trends were presented and discussed. In Michigan, demographic trends are such that Year 2000 population may not be reached for some time. An aging population will reduce working age population while placing demands on health care. The pros and cons of BEA data and BLS data for employment forecasts were given further attention. It appears that Michigan will need international immigration to maintain its labor force.

**Questions from Attendees.** After a 15-minute break, questions from attendees were welcomed by the UMich economists. The questions are listed below to give a flavor of the topics that were raised.

1. Auto employment in Detroit area. How to temper expectations?
2. Where do major employers fit in the forecasts?
3. Which industry code is being used?
4. What are the proper codes to use for the health care industry?
5. How are assumptions on national debt used in REMI?
6. What will be the effect of a “double dip” recession?
7. Do you only use BEA data? What about InfoUSA and Claritas? Have you compared previous forecasts with actual data?
8. How soon do you need comments from MPOs?
9. Explain some more about effects of government and debt.

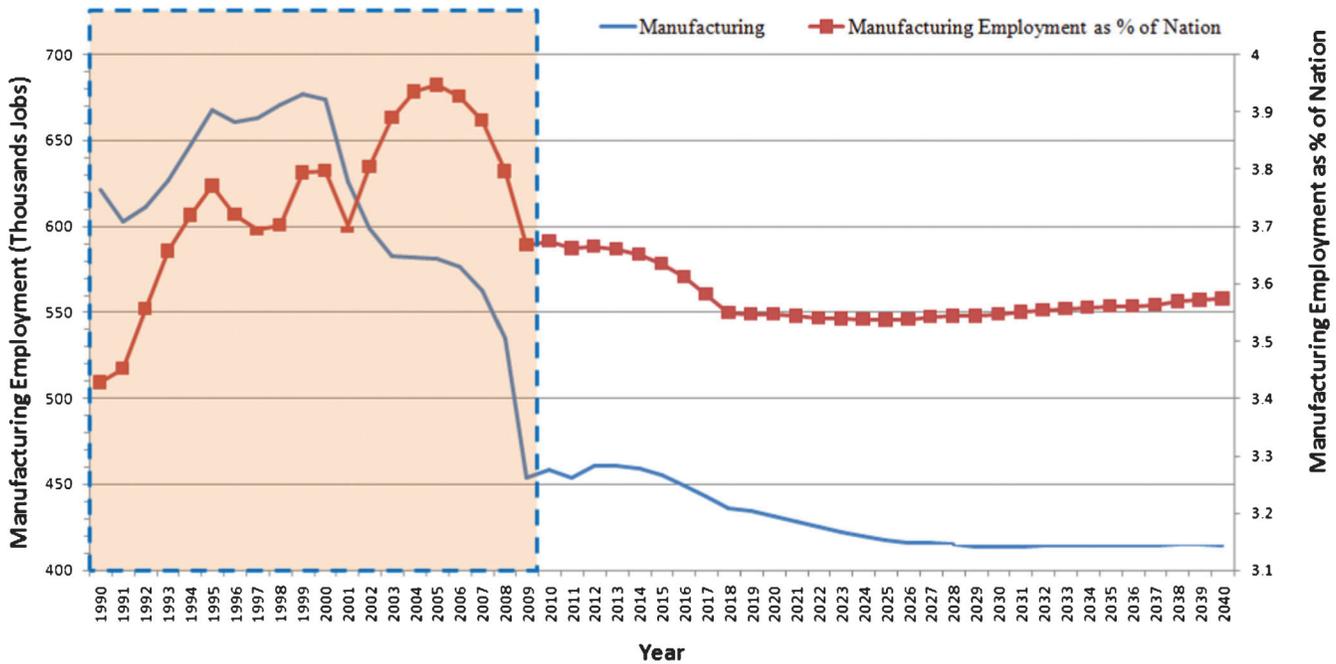


Figure 5.2 REMI baseline forecasts of manufacturing employment for Indiana state. (Data source: (27).)

10. Does the REMI model account for the proximity of Canada to Michigan?
11. Do you account for deflation of assets such as real estate and stocks?
12. We need info for economic impact and travel demand models.
13. A population trough in 2020 or 2011?
14. What about foreclosures, land banking, adaptive reuse, etc.?
15. The maps in the preliminary forecasts show changes in employment and population. Are they consistent?
16. Do you supply migration by age cohort?
17. Can you rerun REMI with a starting year of 1980 and evaluate its results against real trends?
18. What drives growth in the western Upper Peninsula?
19. Do you know about the two new copper mines?
20. Isn't outmigration affected by ability to leave, e.g., ability to sell house?

**Questions “Off Line.”** After the meeting ended, the guest from the Purdue research team for this project sought specific information from several people. The main findings are given below.

1. Questions asked of a representative from Southeast Michigan Council of Governments (SEMCOG), the Detroit-area MPO:
  - a. Q: To what extent is any MPO committed to the statewide forecasts? A: As far as he knows, the MPOs adhere to the statewide forecasts that are broken down by counties and MPOs.
  - b. Q: How do you arrive at TAZ-level model inputs? A: SEMCOG has adopted the UrbanSim land use model. “UrbanSim is a

software-based simulation system for supporting planning and analysis of urban development, incorporating the interactions between land use, transportation, the economy, and the environment” (112). For SEMCOG, UrbanSim takes regional control totals and detailed land use data to allocate activity to the parcel level, which is then aggregated to the TAZ level. These TAZ totals are shared with the affected communities in the Detroit area and adjusted as appropriate.

2. Questions asked of Michigan DOT’s Mr. Banninga:

- a. Q: What kinds of information do you expect to get from the MPOs after this meeting? A: Usually, two types—(1) general comments and questions about the preliminary forecast, expressing doubts or concern about trends in the MPO area, and (2) specific information on local changes in employment or other economic changes.
- b. Q: Do MPOs stick to the state forecasts when using their models? A: Yes, as control totals.
- c. Q: How do MPOs arrive at TAZ-level model inputs? A: They use individual methods.
- d. Other information:
  - i. MPO Directors meet monthly.
  - ii. MPO modelers meet each quarter.
  - iii. The UMich economic forecast is done each 3–4 years.

The TTC meeting seems to have value in two main ways: (1) feedback on the forecasts and insight on happenings in local economies that the state-level

modelers might be unaware of and (2) a higher degree of buy-in by state and local planners and analysts because of their participation in the process.

### 5.3 A Proposal for an Expert Panel in Indiana

As an expert panel, the Michigan Transportation Technical Committee (TTC) is clearly oriented around the impacts on MPO travel demand models of the long-range forecasts produced by economists at the University of Michigan. The economic forecasts are very important as inputs to travel demand models. An especially important input to travel models is employment, to which the models are most sensitive (58). Unfortunately, employment is usually the most difficult data to acquire. The Michigan approach is for MPOs to give the economists the best possible local information with which to refine or adjust their economic forecasts. An alternative approach would be to add perspectives from individuals with greater familiarity with the economic characteristics and trends in various parts of the State of Indiana. For example, economic experts from various parts of Indiana can offer their suggestions and insights to the producers of the preliminary statewide economic forecasts. Likewise, individuals who are involved in, or are familiar with, development (in)activity around the state can offer specific information to improve the economic forecasts for the state.

An expert panel for Indiana could be called the Indiana Economic Forecast Advisory Panel. The panel might consist of:

- Two economists from campuses other than Purdue (West Lafayette) and Indiana University (Bloomington). There are skilled economists at campuses such as Ball State (Muncie) and IU (New Albany) who understand the workings of economic forecasting models and know what kinds of information can make the forecasts better.
- Two members of the development community. For these individuals, information on the future of Indiana's economic climate is critical to their financial success.
- Two members from financial institutions in Indiana that are involved with loans or investments in businesses within the state.
- Two travel demand modelers. The economic forecasts must meet the needs of travel demand models. These modelers can be from MPOs and/or INDOT.
- Two individuals from Indiana state government who have a stake in the economic forecasts. These members could come from the equivalent of the State Department of Commerce and from INDOT's Economic Development Section. Because INDOT will be the principal user of the forecasts, the process must be kept focused on that fact. The Department of Commerce representative may offer access to information not available under normal circumstances.
- The Indiana State Demographer. The economic forecasts depend on, and must be consistent with, the forecasts of the Demographer.

For clear reasons, the membership of the panel must be as geographically diverse as is practical. The Indiana Economic Forecast Advisory Panel could be convened

as a "pilot panel" to test the concept, membership mix, and protocols. Several weeks before the trial meeting, economic forecasts produced by economists designated by INDOT would be distributed to the panel members for their review. At the meeting, the economists would present an overview of the forecasts, with emphasis on its value to INDOT's statewide travel demand model (ISTDM) and those elements of the forecast that could benefit from local input.

## 6. SUMMARY AND FUTURE RESEARCH

### 6.1 Overall Conclusions

INDOT relies on forecasts of demographic and economic variable values in "horizon" years as input to the ISTDM. The REMI model is used by INDOT as a forecasting tool to drive the ISTDM. After reviewing REMI's application in INDOT's Major Corridor Investment-Benefit Analysis System, Indiana's 2010–2035 Transportation Long-Range Plan, and Indiana's Multimodal Freight and Mobility Plan, the role of REMI in socioeconomic forecasting as well as in the economic impacts evaluation of transportation projects was assessed. The REMI models are consistent with the state of the practice in forecasting and impact analysis. A REMI model, like its competitors, is vulnerable to the trends contained in the historical data it uses, especially recent trends. After the most recent periodic update in data, the performance of the REMI PI+ model improved, that is, it produced long-term forecasts that were more credible.

Based on a review of the research literature, transportation infrastructure appears to be a necessary, but not sufficient, condition for generating economic development. Transportation infrastructure has a varying degree of significance on a firm's likelihood to locate in a specific area, combined with four other factors: labor, markets, fiscal, and agglomeration. Each factor has a varying degree of significance on a firm's likelihood to locate in a specific area.

This study reviewed commonly-used socioeconomic data sources. Forecasts that are essential to the running of the ISTDM can come from the REMI model, Woods & Poole forecasting data, STATS Indiana data and its projection package (a CEMR-IBRC model), or a combination of these sources. These sources were evaluated and compared. It was confirmed that the updated REMI version produces credible forecasts that are consistent with Woods & Poole projections in long-term planning years. Zonal level population and employment forecasts for direct input to ISTDM can be achieved by applying BLA disaggregation regression methods to REMI statewide forecasts and Woods & Poole county projections. IU's CEMR-IBRC model is a sound forecasting model and may offer helpful insights into the Indiana economy. Because of the knowledge of in-state economists, the CEMR-IBRC model could provide forecasts of the Indiana economy that reflect characteristics not known to out-of-state forecasters.

The researchers also examined economic impact analysis models that are possible alternatives to REMI. It was found that TREDIS has the most refined township data analysis level and is the only software that can conduct intermodal analysis. Dynamic economic models like REMI TranSight and TREDIS that specialize in transportation investments are able to estimate full economic development impacts over multiple years, but these packages would bring with them added license costs. Acquiring a new economic impact analysis package does not seem necessary for INDOT, if REMI forecasts can be adjusted to (a) accommodate recent and reasonable expected trends in the Indiana economy, and (b) meet the geographic (TAZ) needs of the ISTDM. Comparable to REMI TranSight and TREDIS, MCIBAS—which is currently used by INDOT—is a good hybrid system to use in the economic impacts analysis of transportation projects. REMI PI+ was used to conduct an economic impacts analysis case study of a real improvement project. This case focuses on the process of handling REMI. It particularly emphasized setting up the policy variables in terms of various benefits/costs input from a project, which are less revealed by REMI reference.

IU's Center for Econometric Model Research (CEMR) is capable of conducting economic impact analyses, with local knowledge of the Indiana economy, at a cost lower than REMI's. However, INDOT would have to verify that confidence in a CEMR economic impacts analysis of transportation projects is justified. In cases where the credibility of data, forecasts, and/or impact analyses needs to be verified, an INDOT version of an expert panel along the lines of Michigan's Transportation Technical Committee could be convened.

## 6.2 Future Research

The following research may be of interest to improve the reliability of ISTDM input data and help better understanding the reasonableness of using outputs from REMI or its alternatives in INDOT projects:

- The zonal employment regression model could be further improved by examining potential socioeconomic and traffic and transportation characteristic factors. Also, the effectiveness of breaking a state REMI forecast to county or sub-county units need to be evaluated. Possible county or regional level employment data from MPOs could be collected and aggregated to adjust statewide control totals.
- Sensitivity analysis on REMI economic impacts simulation could be conducted by checking policy variables to help identify the most critical data sources.
- Comparison of the economic impacts analyzed by several popular models or packages need to be further investigated on real transportation projects. Using historical data for INDOT projects, the performance of economic models for use by INDOT could be assessed.

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APPENDIX

TABLE A.1  
Population Change Rates (1910–2010)

	United States		Illinois		Indiana	
	Population	Percent Change	Population	Percent Change	Population	Percent Change
<b>1910</b>	92,228,531	21.00%	5,638,591	16.90%	2,700,876	7.30%
<b>1920</b>	106,021,568	15.00%	6,485,280	15.00%	2,930,390	8.50%
<b>1930</b>	123,202,660	16.20%	7,630,654	17.70%	3,238,503	10.50%
<b>1940</b>	132,165,129	7.30%	7,897,241	3.50%	3,427,796	5.80%
<b>1950</b>	151,325,798	14.50%	8,712,176	10.30%	3,934,224	14.80%
<b>1960</b>	179,323,175	18.50%	10,081,158	15.70%	4,662,498	18.50%
<b>1970</b>	203,211,926	13.30%	11,113,976	10.20%	5,193,669	11.40%
<b>1980</b>	226,545,805	11.50%	11,426,518	2.80%	5,490,224	5.70%
<b>1990</b>	248,709,873	9.80%	11,430,602	0.00%	5,544,159	1.00%
<b>2000</b>	281,421,906	13.20%	12,419,293	8.60%	6,080,485	9.70%
<b>2010</b>	308,745,538	9.70%	12,830,632	3.30%	6,483,802	6.60%

	Kentucky		Michigan		Ohio	
	Population	Percent Change	Population	Percent Change	Population	Percent Change
<b>1910</b>	2,289,905	6.60%	2,810,173	16.10%	4,767,121	14.70%
<b>1920</b>	2,416,630	5.50%	3,668,412	30.50%	5,759,394	20.80%
<b>1930</b>	2,614,589	8.20%	4,842,325	32.00%	6,646,697	15.40%
<b>1940</b>	2,845,627	8.80%	5,256,106	8.50%	6,907,612	3.90%
<b>1950</b>	2,944,806	3.50%	6,371,766	21.20%	7,946,627	15.00%
<b>1960</b>	3,038,156	3.20%	7,823,194	22.80%	9,706,397	22.10%
<b>1970</b>	3,218,706	5.90%	8,875,083	13.40%	10,652,017	9.70%
<b>1980</b>	3,660,777	13.70%	9,262,078	4.40%	10,797,630	1.40%
<b>1990</b>	3,685,296	0.70%	9,295,297	0.40%	10,847,115	0.50%
<b>2000</b>	4,041,769	9.70%	9,938,444	6.90%	11,353,140	4.70%
<b>2010</b>	4,339,367	7.40%	9,883,640	-0.60%	11,536,504	1.60%

Data source: U.S. Census Bureau, 2010 Census (1).

TABLE A.2  
Employment Change Rates (1990–2010)

	United States	Illinois	Indiana	Kentucky	Michigan
1990	0.0137				
1991	-0.0101	-0.0103	-0.0060	0.0029	-0.0156
1992	0.0031	0.0003	0.0186	0.0229	0.0080
1993	0.0195	0.0184	0.0286	0.0260	0.0206
1994	0.0310	0.0247	0.0329	0.0319	0.0361
1995	0.0265	0.0238	0.0273	0.0285	0.0310
1996	0.0204	0.0162	0.0095	0.0176	0.0197
1997	0.0256	0.0153	0.0155	0.0236	0.0192
1998	0.0257	0.0221	0.0206	0.0242	0.0165
1999	0.0244	0.0103	0.0183	0.0244	0.0160
2000	0.0217	0.0144	0.0106	0.0178	0.0205
2001	0.0003	-0.0082	-0.0225	-0.0118	-0.0241
2002	-0.0113	-0.0186	-0.0113	-0.0093	-0.0167
2003	-0.0026	-0.0124	-0.0022	-0.0031	-0.0163
2004	0.0109	0.0011	0.0119	0.0084	-0.0039
2005	0.0173	0.0078	0.0092	0.0145	-0.0018
2006	0.0179	0.0120	0.0065	0.0122	-0.0142
2007	0.0110	0.0079	0.0037	0.0108	-0.0136
2008	-0.0059	-0.0051	-0.0100	-0.0079	-0.0249
2009	-0.0438	-0.0490	-0.0575	-0.0447	-0.0701
2010	-0.0074	-0.0081	0.0030	0.0003	-0.0028
2011	0.0070	0.0098	0.0030	0.0100	0.0143

Data source: U.S. Department of Labor, Bureau of Labor Statistics, Quarterly Census of Employment & Wages (2).

TABLE A.3  
Per Capita Income Change Rates (1991–2010)

	United States	Illinois	Indiana	Kentucky	Michigan	Ohio
1991	0.0240	0.0240	0.0235	0.0509	0.0219	0.0201
1992	0.0495	0.0495	0.0691	0.0624	0.0549	0.0532
1993	0.0282	0.0282	0.0412	0.0236	0.0430	0.0325
1994	0.0426	0.0426	0.0547	0.0430	0.0735	0.0552
1995	0.0433	0.0433	0.0320	0.0366	0.0370	0.0383
1996	0.0507	0.0507	0.0467	0.0529	0.0363	0.0394
1997	0.0496	0.0496	0.0420	0.0520	0.0441	0.0581
1998	0.0625	0.0625	0.0662	0.0582	0.0613	0.0605
1999	0.0394	0.0394	0.0290	0.0354	0.0355	0.0331
2000	0.0701	0.0701	0.0603	0.0762	0.0551	0.0513
2001	0.0274	0.0274	0.0213	0.0231	0.0201	0.0195
2002	0.0103	0.0103	0.0166	0.0193	0.0070	0.0192
2003	0.0258	0.0258	0.0362	0.0191	0.0335	0.0273
2004	0.0500	0.0500	0.0364	0.0437	0.0144	0.0298
2005	0.0456	0.0456	0.0213	0.0369	0.0197	0.0275
2006	0.0643	0.0643	0.0501	0.0542	0.0290	0.0484
2007	0.0468	0.0468	0.0303	0.0379	0.0312	0.0337
2008	0.0308	0.0308	0.0353	0.0356	0.0312	0.0236
2009	-0.0251	-0.0251	-0.0277	-0.0009	-0.0269	-0.0143
2010	0.0228	0.0228	0.0261	0.0333	0.0358	0.0269

Data source: U.S. Department of Commerce, Bureau of Economic Analysis, State Annual Personal Income Data (3).

TABLE A.4  
Total Employment and Total Population Forecasts (2000–2040)

	Total Employment (Thousands)			Total Population (Thousands)		
	REMI	Woods & Poole	STATS Indiana	REMI	Woods & Poole	STATS Indiana
2000	3647.19	3647.09	2934.50	6091.65	6091.65	6091.52
2001	3588.31	3588.11	2871.24	6124.97	6124.97	6124.09
2002	3547.17	3547.03	2832.55	6149.01	6149.01	6148.65
2003	3547.90	3547.66	2821.88	6181.79	6181.79	6184.55
2004	3586.61	3586.42	2848.87	6214.45	6214.45	6214.84
2005	3626.25	3626.25	2873.80	6253.12	6253.12	6253.14
2006	3665.71	3665.74	2892.42	6301.70	6301.70	6300.34
2007	3714.04	3714.07	2905.73	6346.11	6346.11	6344.77
2008	3717.82	3718.15	2872.44	6388.31	6388.31	6386.60
2009	3470.80	3486.87	2705.33	6415.09	6423.11	6417.28
2010	3458.82	3433.12	2709.40	6451.87	6461.24	6445.30
2011	3496.97	3519.38	2767.52	6492.20	6499.35	6472.61
2012	3575.93	3551.95	2825.64	6535.58	6538.25	6499.93
2013	3636.42	3584.78	2883.76	6579.08	6577.83	6527.24
2014	3684.21	3617.76	2941.88	6620.97	6618.14	6554.56
2015	3721.62	3650.96	3000.00	6660.82	6658.85	6581.88
2016	3745.76	3684.31	3040.00	6698.50	6700.01	6613.33
2017	3762.47	3717.93	3080.00	6734.26	6741.68	6644.78
2018	3779.28	3751.71	3120.00	6768.62	6783.60	6676.23
2019	3813.09	3785.71	3160.00	6804.49	6825.91	6707.68
2020	3840.91	3819.89	3200.00	6841.79	6868.37	6739.13
2021	3869.79	3854.67	3220.00	6880.14	6911.63	6768.86
2022	3896.97	3889.45	3240.00	6919.68	6954.89	6798.59
2023	3925.72	3924.23	3260.00	6960.75	6998.15	6828.33
2024	3953.89	3959.01	3280.00	7003.00	7041.41	6858.06
2025	3980.95	3993.79	3300.00	7046.72	7084.67	6887.79
2026	4009.21	4029.54	3334.00	7092.00	7128.16	6913.98
2027	4040.41	4065.30	3368.00	7138.80	7171.66	6940.16
2028	4070.99	4101.06	3402.00	7186.48	7215.15	6966.34
2029	4102.05	4136.81	3436.00	7235.13	7258.64	6992.53
2030	4136.18	4172.57	3470.00	7284.58	7302.13	7018.71
2031	4171.79	4209.28	3504.00	7335.04	7345.59	7039.95
2032	4208.86	4246.00	3538.00	7386.34	7389.05	7061.19
2033	4246.94	4282.71	3572.00	7438.52	7432.51	7082.43
2034	4283.87	4319.42	3606.00	7491.53	7475.97	7103.67
2035	4319.91	4356.14	3640.00	7545.46	7519.43	7124.92
2036	4356.94	4393.80	3674.00	7600.42	7563.23	7142.69
2037	4395.79	4431.46	3708.00	7656.50	7607.04	7160.46
2038	4433.61	4469.12	3742.00	7713.63	7650.84	7178.24
2039	4470.12	4506.79	3776.00	7772.29	7694.65	7196.01
2040	4503.09	4544.45	3810.00	7832.44	7738.45	7213.78

TABLE A.5  
**School Enrollment in Indiana State (2006–2010)**

	2006	2007	2008	2009	2010
<b>Pre-School</b>	139	145	231	200	346
<b>Pre-Kindergarten</b>	12,385	11,730	12,599	14,189	15,661
<b>Kindergarten</b>	81,181	85,374	81,567	82,110	84,388
<b>Grade 1</b>	86,766	88,709	91,350	86,925	86,003
<b>Grade 2</b>	84,212	85,303	86,502	88,890	85,033
<b>Grade 3</b>	83,545	83,962	84,722	85,667	88,183
<b>Grade 4</b>	84,947	84,137	84,070	84,566	85,705
<b>Grade 5</b>	84,624	85,560	84,592	84,171	84,553
<b>Grade 6</b>	85,027	85,651	85,759	84,486	84,444
<b>Grade 7</b>	87,247	86,237	86,531	86,376	84,994
<b>Grade 8</b>	87,118	87,148	86,034	86,152	86,116
<b>Grade 9</b>	92,727	91,415	88,965	88,962	89,005
<b>Grade 10</b>	85,437	87,022	86,002	85,500	85,603
<b>Grade 11</b>	77,948	81,177	82,448	81,538	82,378
<b>Grade 12</b>	70,808	73,712	75,616	76,866	77,484
<b>Grade 12+/Adult</b>	394	411	477	742	1,013

Data source: Indiana K-12 education data (5).

TABLE A.6  
Case Study REMI Simulation Results

Category Unit	Total Employment Thousands (Jobs)	Private Non-Farm Employment Thousands (Jobs)	Gross Domestic Product Billions of Fixed (2005) Dollars
1990	3069.859	2583.853	154.611
1991	3071.898	2583.955	156.348
1992	3120.733	2626.878	162.654
1993	3197.336	2699.263	169.25
1994	3287.373	2793.056	176.772
1995	3379.437	2888.98	180.843
1996	3418.095	2925.687	186.825
1997	3476.388	2983.657	193.849
1998	3545.63	3048.123	199.547
1999	3598.678	3096.533	207.086
2000	3647.192	3136.07	209.76
2001	3588.312	3080.364	206.077
2002	3547.165	3044.868	212.779
2003	3547.903	3040.827	218.821
2004	3586.61	3082.249	224.36
2005	3626.252	3121.747	227.863
2006	3665.713	3157.528	229.238
2007	3714.035	3198.667	231.129
2008	3717.817	3197.546	231.61
2009	3470.795	2968.977	218.858
2010	3462.19	2961.24	226.902
2011	3498.78	3002.065	232.081
2012	3577.722	3085.178	240.896
2013	3638.167	3140.261	249.316
2014	3685.925	3183.018	257.979
2015	3723.285	3216.113	266.58
2016	3747.379	3236.458	275.459
2017	3764.03	3250.037	284.707
2018	3780.802	3264.083	294.399
2019	3814.584	3293.049	302.638
2020	3842.391	3317.488	308.914
2021	3871.251	3342.95	315.381
2022	3898.41	3366.98	321.827
2023	3927.141	3392.358	328.547
2024	3955.31	3417.21	335.359
2025	3982.354	3440.998	342.278
2026	4010.588	3465.753	349.51
2027	4041.781	3493.011	357.342
2028	4072.355	3519.706	365.193
2029	4103.402	3546.664	373.176
2030	4137.538	3576.53	381.738

Data source: REMI PI+ Indiana v1.2.4 (Build 2199) (6).

## APPENDIX REFERENCES

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